CPC400 Series
User's Guide

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1

System Overview

Manual Contents

This manual describes how to install, set up, and operate a CPC400 series controller. Each chapter covers a different aspect of your control system and may apply to different users:

- **Chapter 1: System Overview** provides a component list and summary of features for the CPC400 series controllers.
- **Chapter 2: Installation** provides detailed instructions on installing the CPC400 series controller and its peripherals.
- **Chapter 3: Operation and Setup** provides instructions about operating and setting up the CPC400.
- **Chapter 4: Tuning and Control** describes available control algorithms and suggestions for applications.
- **Chapter 5: Menu and Parameter Reference** provides detailed descriptions of all menus and parameters for controller setup and for accessing parameter and I/O values with a LogicPro program or via the serial communications interface.
- **Chapter 6: Troubleshooting and Reconfiguring** includes troubleshooting, upgrading and reconfiguring procedures for technical personnel.
- **Chapter 7: Specifications** lists detailed specifications of the controller and optional components.
- **Appendix: Modbus Reference** describes the Modbus RTU communications protocol, which is used to read and set parameter values through the serial communications interface. This information is intended for programmers writing software to communicate with the CPC400.
- **Parameter Address Reference** provides a way to quickly locate parameter addresses.

Getting Started

Safety Symbols

These symbols are used throughout this manual:

WARNING! ***Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.***

CAUTION! ***Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury or property damage.***

NOTE! ***Indicates pertinent information or an item that may be useful to document or label for later reference.***

Initial Inspection

Accessories may or may not be shipped in the same container as the CPC400, depending upon their size. Check the shipping invoice against the contents received in all boxes.

Product Features

CPC400 series controllers offer high-performance closed-loop control and user-programmable logic to manipulate process control algorithms and sequential logic.

The CPC400 provides four or eight independent control loops with analog inputs—thermocouples, RTDs and process. An additional 2 kHz pulse loop is also provided.

When used as a stand-alone controller, you may operate the CPC400 via the two-line 16-character display and touch keypad. You can also use it as the key element in a computer-supervised data acquisition and control system. The CPC400 can be locally or remotely controlled via an EIA/TIA-232 or EIA/TIA-485 serial communications interface.

CPC400 features include:

- **TRU-TUNE+™Adaptive Control**: Enable adaptive control using the unique TRU-TUNE+™ adaptive algorithm and optimize even difficult-to-control or dynamic processes. TRU-TUNE+™ monitors the process variable and adjusts the control parameters automatically to keep your process at set point and optimize for set point and load changes.
- **User-Programmable Logic**: Customize the controller to run custom closed-loop control algorithms or processes. All closed-loop control parameters and system I/O are available for user programs. Program and closed-loop control variables can be shared or independent. Use LogicPro software to write, monitor and debug logic programs.
- **Direct Connection of Mixed Thermocouple Sensors:** Connect most thermocouples to the controller with no hardware modifications. Thermocouple inputs feature reference junction compensation, linearization, offset calibration to correct for sensor inaccuracies, detection of open, shorted or reversed thermocouples, and a choice of Fahrenheit or Celsius display.
- **Accepts Resistive Temperature Detectors (RTDs):** Use three-wire, 100 Ω, platinum, 0.00385-curve sensors. Special inputs must be installed.
- **Automatic Scaling for Process Analog Inputs:** The CPC400 series automatically scales process inputs used with industrial process sensors. Enter two points, and all input values are automatically scaled. Special inputs must be installed.
- **Dual Outputs:** The CPC400 series includes both heat and cool control outputs for each loop. Independent control parameters are provided for each output.
- **Independently Selectable Control and Output Modes:** Set each control output to on/off, time proportioning, Serial DAC (digital-to-analog converter) or distributed zero crossing mode. Set up to two outputs per loop for on/off, P, PI or PID control with reverse or direct action.
- **Boost Output Function:** Set digital outputs to function as boost on/off control in association with any alarm.
- **Flexible Alarms:** Independently set high and low alarms and high and low deviation alarms for each loop. Alarms can activate a digital output by themselves, or they can be grouped with other alarms to activate an output.
- **Global Alarm Output:** Any alarm event activates the global alarm output.
- **CPU Watchdog:** The CPU watchdog timer output notifies you of system failure.

- **Keypad or Computer Operation:** Set up and run the controller from the keypad or from a local or remote computer. Use WATVIEW HMI software to set up the controller, manage jobs (recipes), log data or monitor system performance.
- **Modbus RTU Protocol, EIA/TIA-232 and 485 Communications:** Connect operator interface terminals and third-party software packages using the widely supported Modbus RTU protocol.
- **Multiple Job Storage:** Store up to eight jobs in the controller's battery-backed memory. Load a job through the keypad, digital inputs or software. Each job is a set of operating conditions, including set points and alarm limits.
- **Nonlinear Output Curves:** Select either of two nonlinear output curves for each control output.
- **Pulse Input:** Use the pulse input for precise control of motor or belt speed.
- **Low Power Shutdown:** The controller shuts down and turns off all outputs when it detects the input voltage drop below the minimum safe operating level.
- **Process Variable Retransmit:** Scale a temperature or process and convert it to an analog output for external devices such as chart recorders.
- **Two-Zone Cascade Control:** Control thermal systems with long lag times, which cannot be accurately controlled with a single loop.
- **Ratio or Offset Control:** Control one process as a ratio or offset of another process.
- **Remote Analog Set Point:** Scale an external voltage or current source to provide a set point for a loop.

CPC400 Parts List

You may have received one or more of the following components. See *Figure 2.1 on page 12* for CPC400 configuration information.

- CPC400 series controller
- Controller mounting kit
- TB50 with 50-pin SCSI cable
- EIA/TIA-232 or EIA/TIA-485 communications cable
- Power supply with mounting bracket and screws
- Serial DAC (digital-to-analog converter)
- Special input resistors (installed in CPC400)
- User's guide

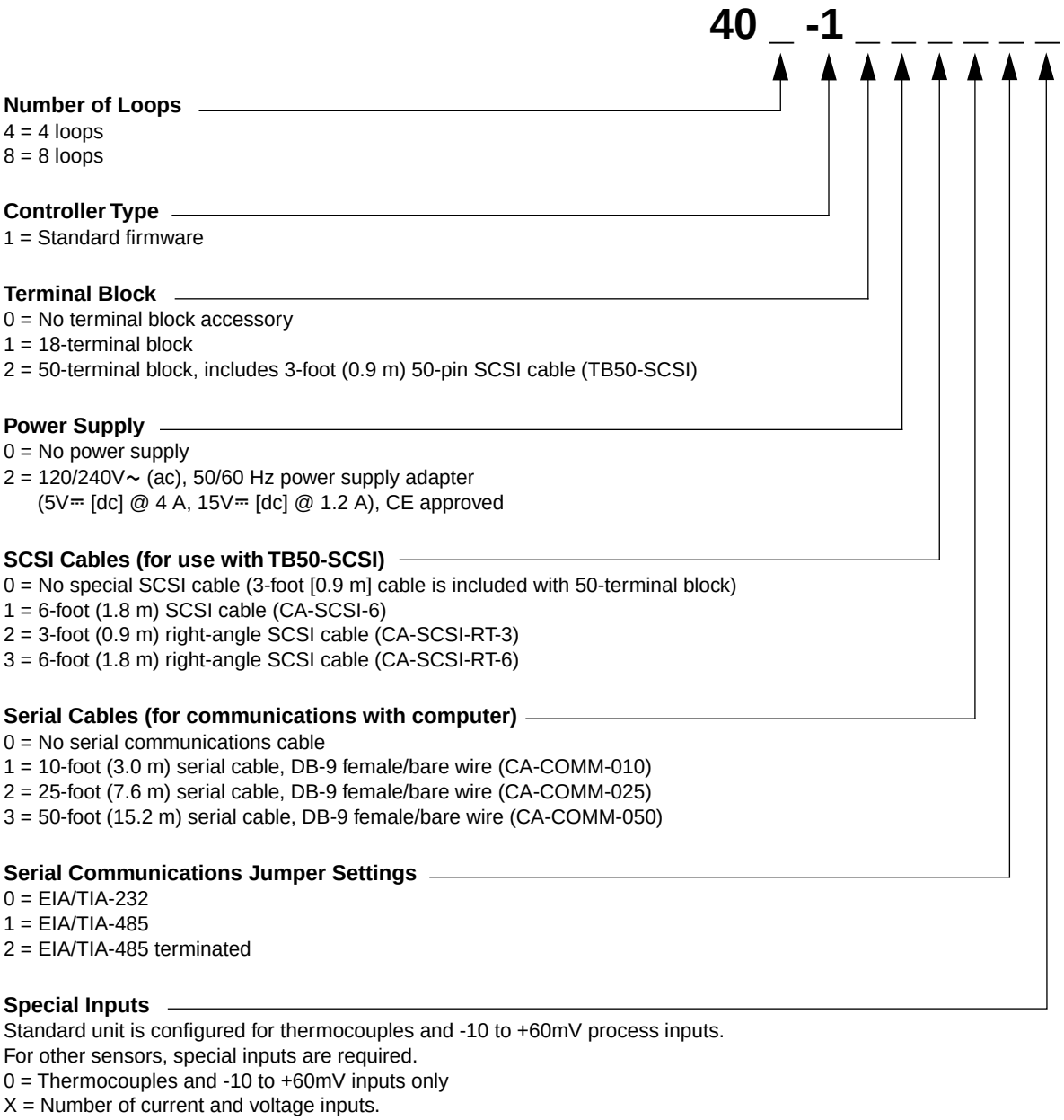


Figure 1.1 CPC400 Standard Parts List

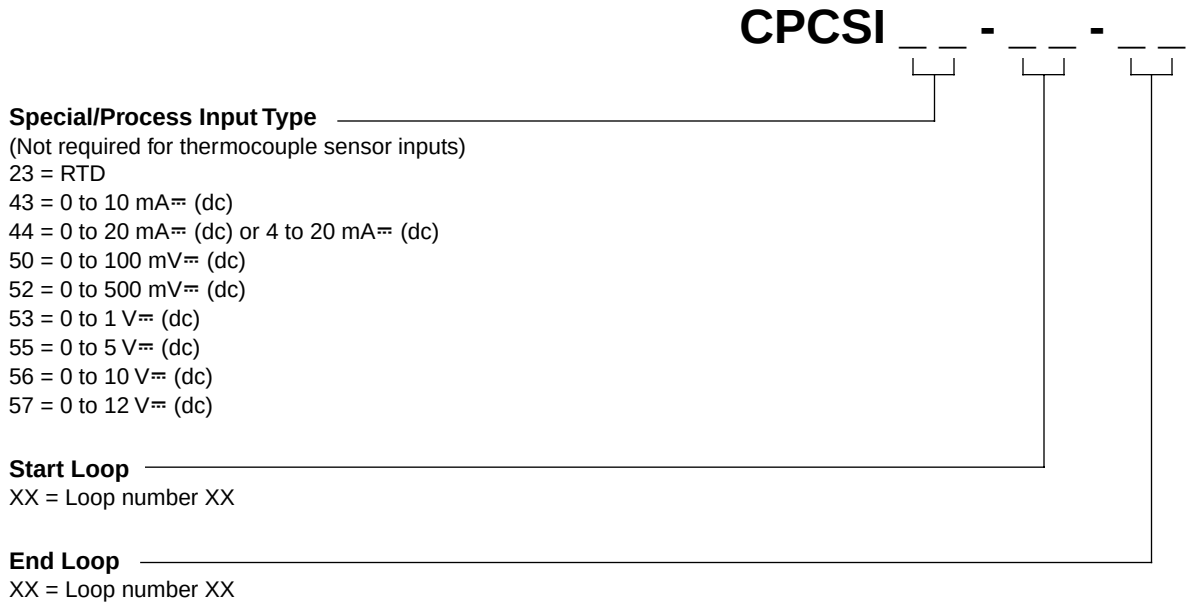


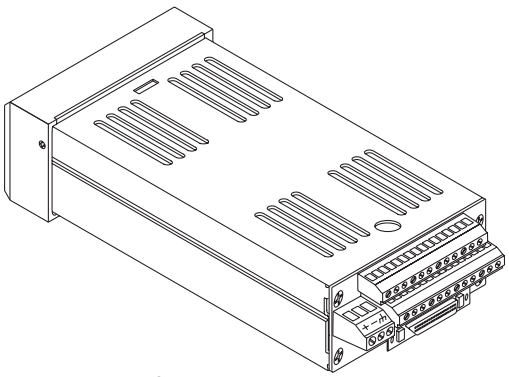
Figure 1.2 CPC400 Special Inputs Parts List

Technical Description

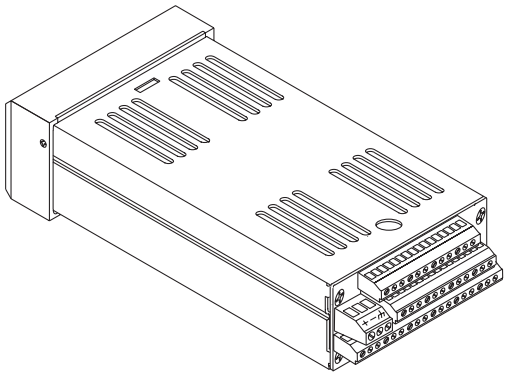
This section contains a technical description of each component of the CPC400 series controller.

CPC400

The CPC400 is housed in a 1/8-DIN panel mount package. It contains the central processing unit (CPU), random access memory (RAM) with a built-in battery, flash memory, serial communications, digital I/O, analog inputs, display and touch keypad.



CPC400 Series
with SCSI Connector



CPC400 Series
with TB18 Connector

Figure 1.3 CPC400 Rear Views

The CPC400 has the following features:

- Keypad and two-line, 16-character display.
- Screw terminals for the power and analog inputs and communications.
- Input power of 12 to 24 V⎓ (dc) at 1 Amp.
- 50-pin SCSI cable to connect the digital inputs and outputs to the 50-terminal block (TB50). The CPC400 is available with an 18-terminal block (TB18) in place of the SCSI connector, as shown in *Figure 1.3 on page 6*.
- Nonvolatile flash memory for storage of firmware and programmable logic.
- Battery-backed storage of operating parameters. If a power loss occurs, the operating parameters are stored in memory. The battery has a ten-year shelf life, and it is not used when the controller is on.
- Microprocessor control of all calculations for input signal linearization, PID control, alarms, and communications.

Front Panel Description

The display and keypad provide an intelligent way to operate the controller. The display has 16 alphanumeric or graphic characters per line. The eight-key keypad allows you to change the operating parameters, controller functions and displays.

The displays show process variables, set points and output levels for each loop. A single-loop display, scanning display and alarm display offer a real-time view of process conditions.

For useful tips, help and menu information, press **i** from any screen.

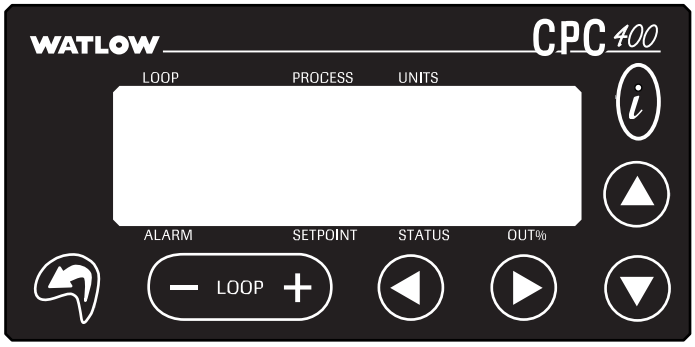


Figure 1.4 CPC400 Front Panel

TB50

The TB50 is a screw-terminal interface for control wiring. It allows you to connect relays, encoders and discrete I/O devices to the CPC400. The screw terminal blocks accept wires as large as 18 AWG (0.75 mm^2). A 50-pin SCSI cable connects the TB50 to the CPC400.

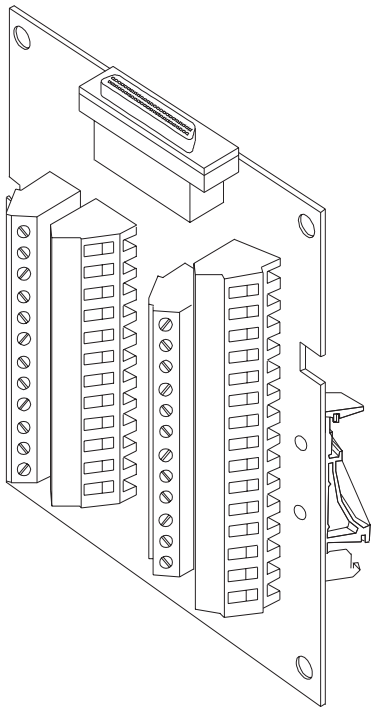


Figure 1.5 TB50

CPC400 Cabling

Watlow Anafaze provides cables required to install the CPC400. A 50-pin SCSI cable connects the TB50 to the CPC400.

The optional cable used to connect the CPC400 to a computer using EIA/TIA-232 communications has a DB-9 or DB-25 connector for the computer and bare wires for connecting to the CPC400.

Safety

Watlow Anafaze has made every effort to ensure the reliability and safety of this product. In addition, we have provided recommendations that will allow you to safely install and maintain this controller.

External Safety Devices

The CPC400 controller may fail full-on (100 percent output power) or full-off (0 percent output power), or may remain full-on if an undetected sensor failure occurs.

Design your system to be safe even if the controller sends a 0 percent or 100 percent output power signal at any time. Install independent, external safety devices such as the Watlow Anafaze TLM-8 that will shut down the system if a failure occurs.

Typically, a shutdown device consists of an agency-approved high/low process limit controller that operates a shutdown device such as an mechanical contactor. The limit controller monitors for a hazardous condition such as an under-temperature or over-temperature fault. If a hazardous condition is detected, the limit controller sends a signal to open the contactor.

The safety shutdown device (limit controller and contactor) must be independent from the process control equipment.

WARNING! ***The controller may fail in a 0 percent or 100 percent output power state. To prevent death, personal injury, equipment damage or property damage, install external safety shutdown devices that operate independently from the process control equipment.***

With proper approval and installation, thermal fuses may be used in some processes.

Power-Fail Protection

In the occurrence of a sudden loss of power, the CPC400 controller can be programmed to reset the control outputs to off (this is the default). The controller can also be configured to restart to data stored in memory.

A memory-based restart might create an unsafe process condition for some installations. Use a memory-based restart only if you are certain your system will safely restart. See *Power Up Loop Mode on page 100*.

When using a computer or host device, you can program the software to automatically reload desired operating constants or process values on powerup. These convenience features do *not* eliminate the need for independent safety devices.

Contact Watlow Anafaze immediately if you have any questions about system safety or system operation.

2

Installation

This chapter describes how to install the CPC400 series controller and its peripherals. Installation of the controller involves the following procedures:

- Determining the best location for the controller
- Mounting the controller and TB50
- Power connection
- Input wiring
- Communications wiring (EIA/TIA-232 or EIA/TIA-485)
- Output wiring

WARNING! ***Risk of electric shock. Shut off power to your entire process before you begin installation of the controller.***

WARNING! ***The controller may fail in a 0 percent or 100 percent power output state. To prevent death, personal injury, equipment damage or property damage, install external safety shutdown devices that operate independently from the process control equipment.***

Typical Installation

Figure 2.1 shows typical installations of the controller with the TB50 and the TB18 terminal blocks. The type of terminal block you use greatly impacts the layout and wiring of your installation site. See *Figure 2.2* to *Figure 2.10* to determine potential space requirements.

We recommend that you read this entire chapter before beginning the installation procedure. This will help you to carefully plan and assess the installation.

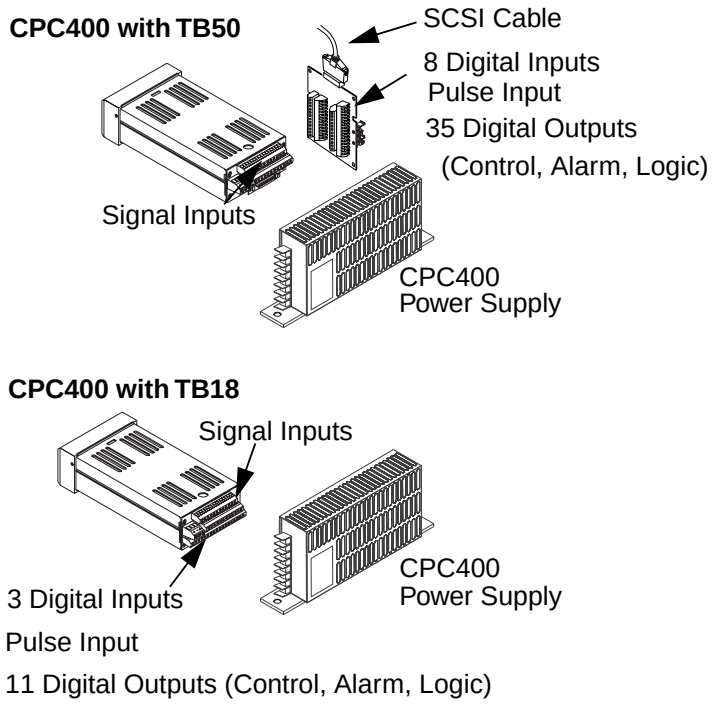


Figure 2.1 CPC400 System Components

Mounting Controller Components

Install the controller in a location free from excessive heat (>50º C), dust and unauthorized handling. Electromagnetic and radio frequency interference can induce noise on sensor wiring. Choose locations for the CPC400 and TB50 such that wiring can be routed clear of sources of interference such as high voltage wires, power switching devices and motors.

NOTE! ***For indoor use only.***

WARNING! ***To reduce the risk of fire or electric shock, install the CPC400 in a controlled environment, relatively free of contaminants.***

Recommended Tools

Use any of the following tools to cut a hole of the appropriate size in the panel.

- Jigsaw and metal file, for stainless steel and heavyweight panel doors.
- Greenlee 1/8-DIN rectangular punch (Greenlee part number 600-68), for most panel materials and thicknesses.
- Nibbler and metal file, for aluminum and lightweight panel doors.

You will also need these tools:

- Phillips head screwdriver
- 1/8-inch (3 mm) flathead screwdriver for wiring
- Multimeter

Mounting the Controller

Mount the controller before you mount the terminal block or do any wiring. The controller's placement affects placement and wiring considerations for the other components of your system.

Ensure that there is enough clearance for mounting brackets, terminal blocks, and cable and wire connections. The controller extends up to 7.0 inches (178 mm) behind the panel face and the screw brackets extend 0.5 inch (13 mm) above and below it. If using a straight SCSI cable, allow for an additional 1.6 inches (41 mm) beyond the terminal block. If using a right-angle SCSI cable, allow an additional 0.6 inch (15 mm). Refer to *Figure 2.2*.

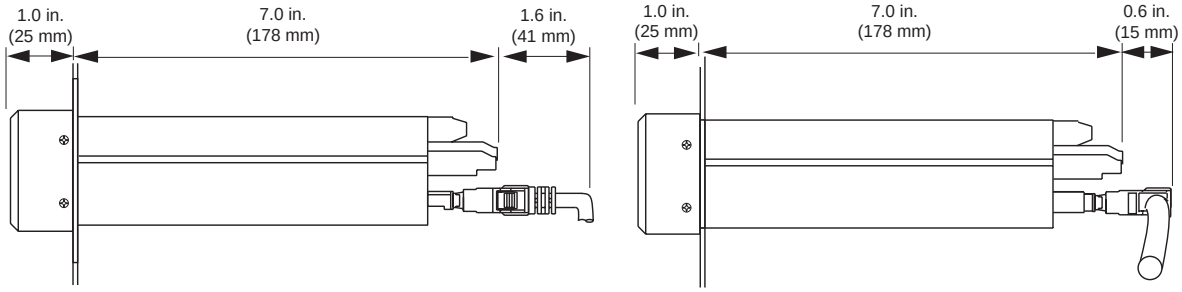


Figure 2.2 Clearance with Straight SCSI Cable (L) and Right-Angle SCSI Cable (R)

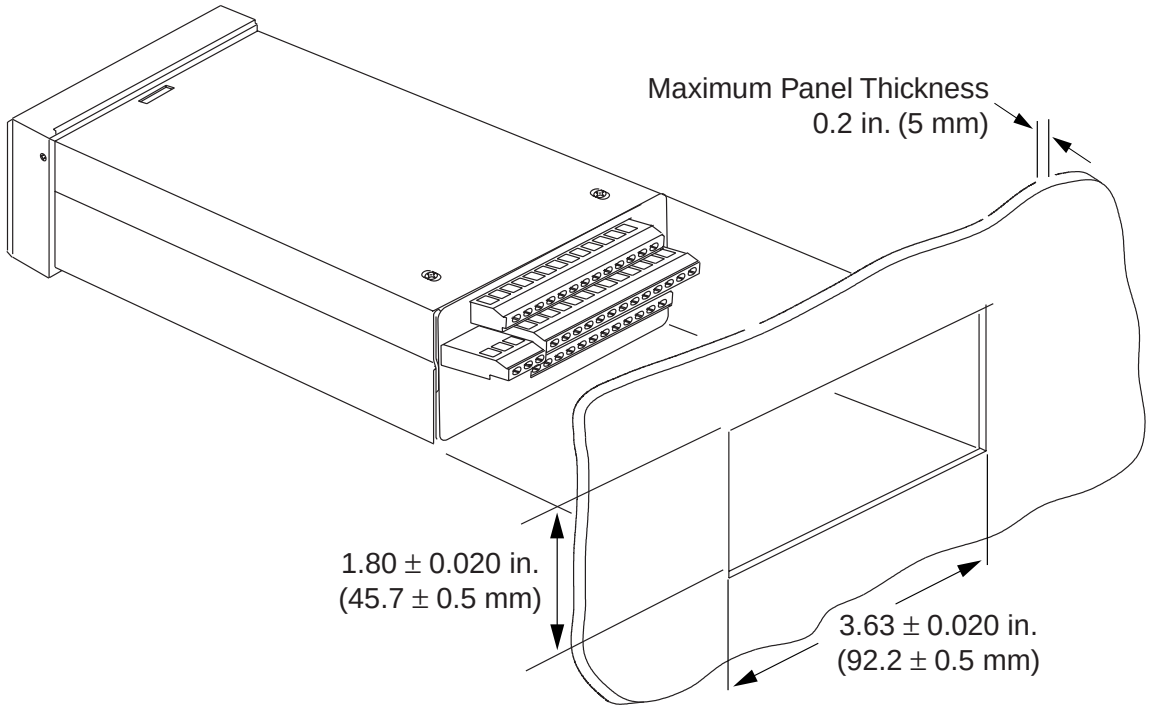


Figure 2.3 Wiring Clearances

We recommend you mount the controller in a panel not more than 0.2 in. (5 mm) thick.

1. Choose a panel location free from excessive heat (more than 50° C [122° F]), dust, and unauthorized handling. (Make sure there is adequate clearance for the mounting hardware, terminal blocks, and cables. The controller extends 7.0 in. (178 mm) behind the panel.

Allow for an additional 0.60 to 1.60 in. (15 to 41 mm) beyond the connectors.)

2. Temporarily cover any slots in the metal housing so that dirt, metal filings, and pieces of wire do not enter the housing and lodge in the electronics.
3. Cut a hole in the panel 1.80 in. (46 mm) by 3.63 in. (92 mm) as shown below. Use caution; the dimensions given here have 0.02 in. (0.5 mm) tolerances.
4. Remove the brackets and collar from the processor module, if they are already in place.
5. Slide the processor module into the panel cutout.
6. Slide the mounting collar over the back of the processor module, making sure the mounting screw indentations face toward the back of the processor module.

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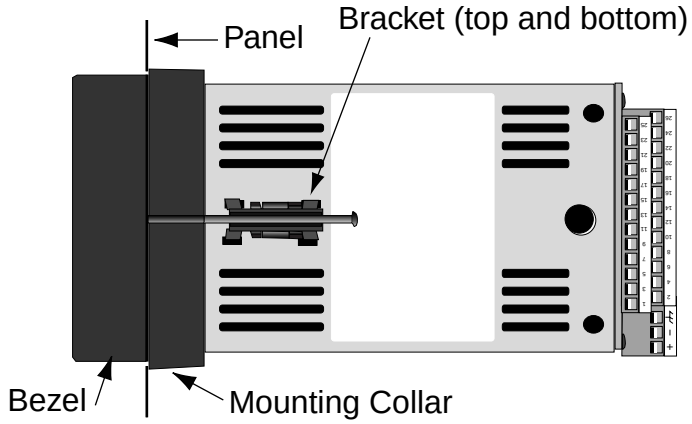


Figure 2.4 Mounting Bracket

7. Loosen the mounting bracket screws enough to allow for the mounting collar and panel thickness. Place each mounting bracket into the mounting slots (head of the screw facing the back of the processor module). Push each bracket backward then to the side to secure it to the processor module case.
8. Make sure the case is seated properly. Tighten the installation screws firmly against the mounting collar to secure the unit. Ensure that the end of the mounting screws fit into the indentations on the mounting collar.

Mounting the TB50

There are two ways to mount the TB50: Use the pre-installed DIN rail mounting brackets or use the plastic standoffs.

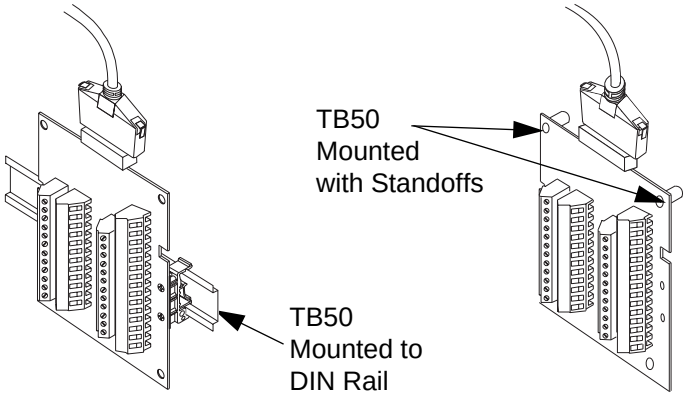


Figure 2.5 Mounting the TB50

DIN Rail Mounting

Snap the TB50 on to the DIN rail by placing the hook side on the rail first, then pushing the snap latch side in place. See *Figure 2.6*.

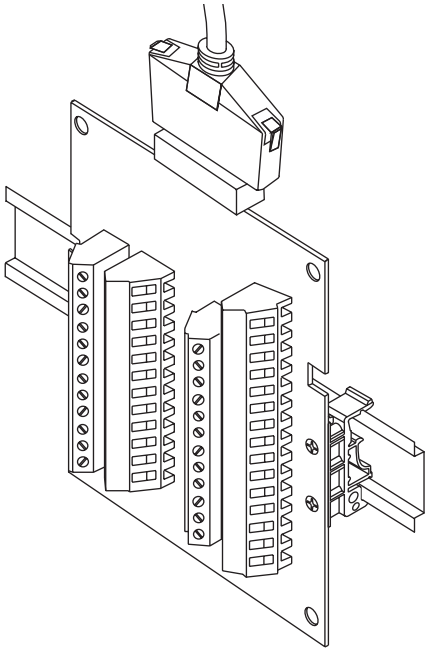


Figure 2.6 TB50 Mounted on a DIN Rail (Front)

To remove the TB50 from the rail, use a flathead screw driver to unsnap the bracket from the rail. See *Figure 2.7*.

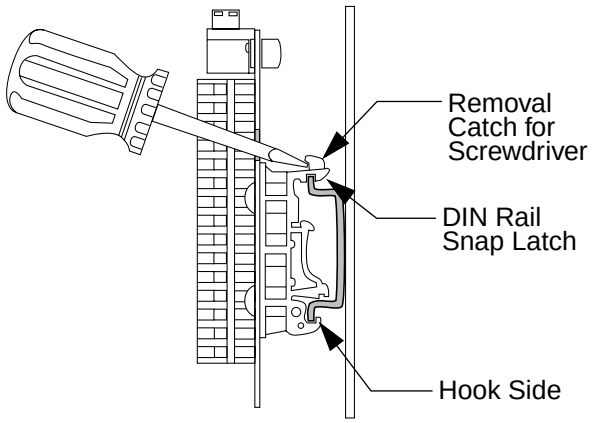


Figure 2.7 TB50 Mounted on DIN Rail (Side)

Mounting with Standoffs

1. Remove the DIN rail mounting brackets from the TB50.
2. Choose a location with enough clearance to remove the TB50, its SCSI cable and the controller itself.
3. Mark the four mounting holes.
4. Drill and tap four mounting holes for #6 (3.5 mm) screws or bolts.
5. Mount the TB50 with four screws or bolts.

There are four smaller holes on the terminal board. Use these holes to secure wiring to the terminal block with tie wraps.

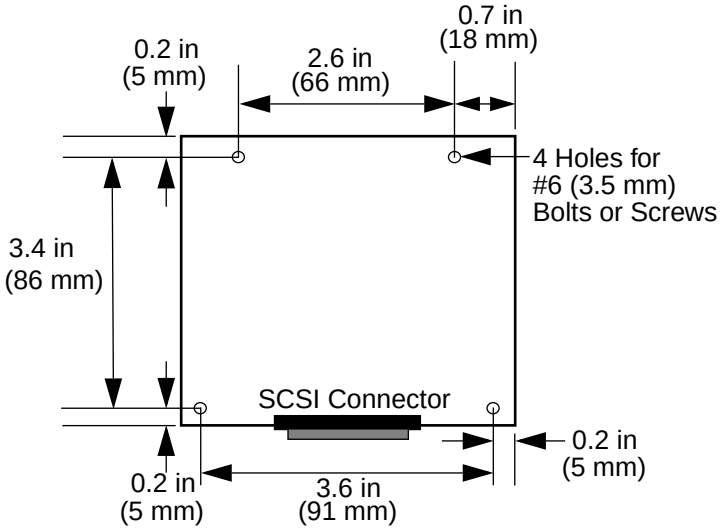


Figure 2.8 Mounting a TB50 with Standoffs

Mounting the Power Supply

If you use your own power supply for the CPC400, refer to the power supply manufacturer's instructions for mounting information. Choose a Class 2 power supply that supplies an isolated, regulated 12 to 24V⎓ (dc) at 1 A.

Mounting Environment

Leave enough clearance around the power supply so that it can be removed.

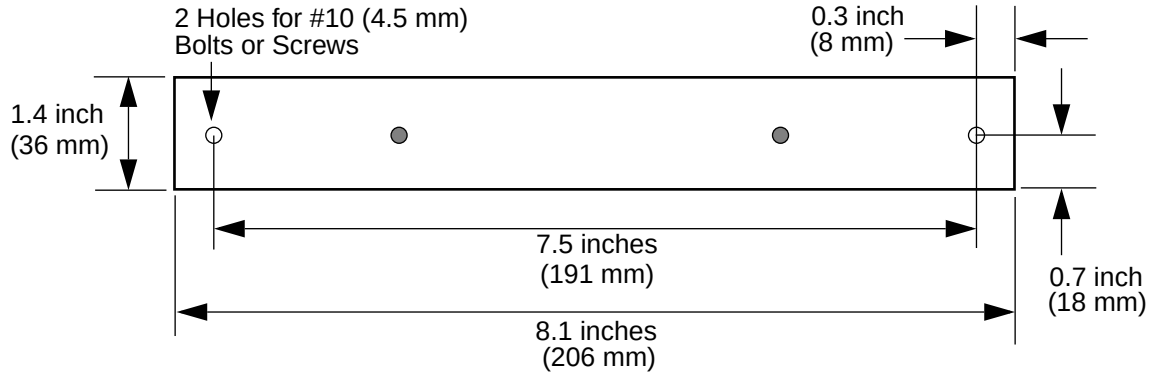


Figure 2.9 CPC400 Power Supply Mounting Bracket

Mounting Steps

CAUTION! ***When attaching the bracket to the power supply, use screws that are no longer than 1/4-inch (6 mm) long. Longer screws may extend too far into the power supply and short to components, damaging the power supply.***

1. Attach the bracket to the power supply using the two center holes in the bracket.
2. Choose a location with enough clearance to remove the power supply and bracket.
3. Mark the bracket's two outer holes for mounting.
4. Drill and tap the two mounting holes. The bracket holes accept up to #10 (4.5 mm) screws.
5. Mount the power supply on the panel.
6. Tighten the screws.

Mounting the Dual DAC or Serial DAC Module

This section describes how to mount the optional Dual DAC and Serial DAC digital-to-analog converters.

Mounting of the Dual DAC and Serial DAC is essentially the same, except that the dimensions differ.

Jumpers

The output signal range of the Dual DAC and Serial DAC modules is configured with jumpers. See *Configuring Dual DAC Outputs on page 163* and *Configuring Serial DAC Outputs on page 162* for information about setting these jumpers.

Mounting

1. Choose a location. The unit is designed for wall mounting. Install it as close to the controller as possible.
2. Mark and drill four holes for screw mounting. Holes accommodate #8 (3.5 mm) screws. See *Figure 2.10* for screw locations. Install the unit with the four screws.

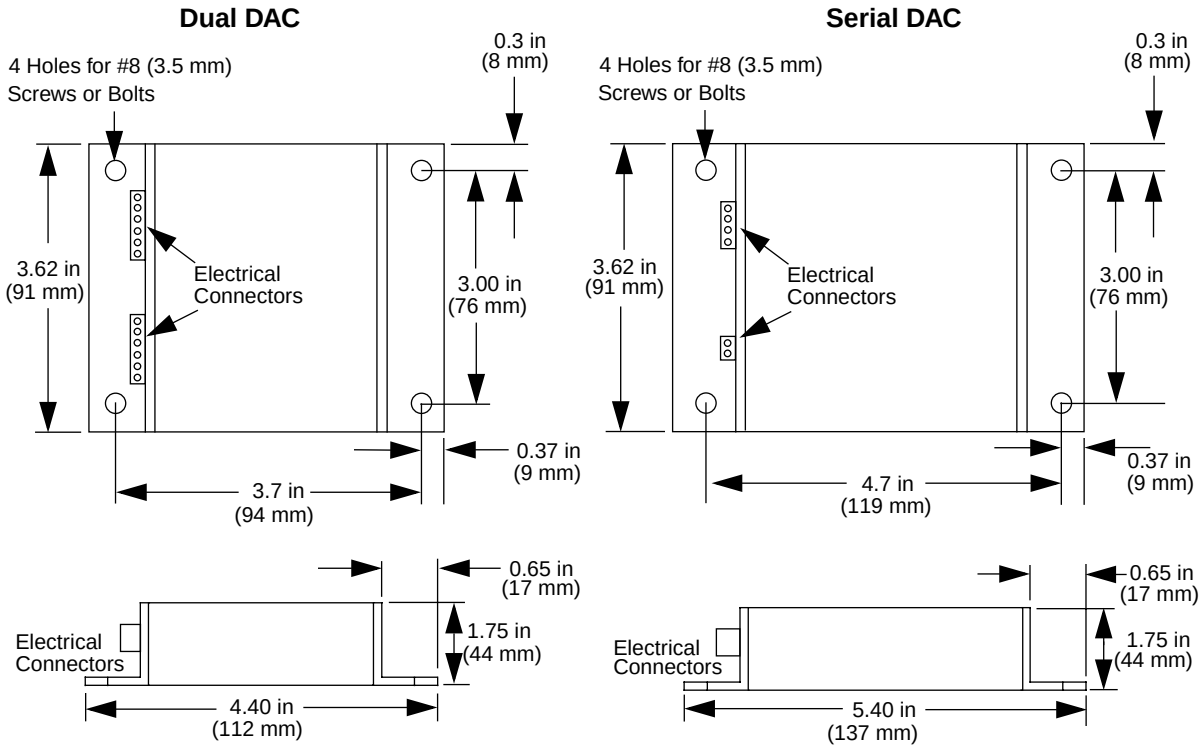


Figure 2.10 Dual DAC and Serial DAC Dimensions

System Wiring

Successful installation and operation of the control system can depend on placement of the components and on selection of the proper cables, sensors and peripheral components.

Routing and shielding of sensor wires and proper grounding of components can insure a robust control system. This section includes wiring recommendations, instructions for proper grounding and noise suppression, and considerations for avoiding ground loops.

WARNING! ***To reduce the risk of electrical shock, fire, and equipment damage, follow all local and national electrical codes. Correct wire sizes, fuses and thermal breakers are essential for safe operation of this equipment.***

CAUTION! ***Do not wire bundles of low-voltage signal and control circuits next to bundles of high-voltage ac wiring. High voltage may be inductively coupled onto the low-voltage circuits, which may damage the controller or induce noise and cause poor control.***

Physically separate high-voltage circuits from low-voltage circuits and from CPC400 hardware. If possible, install high-voltage ac power circuits in a separate panel.

Wiring Recommendations

Follow these guidelines for selecting wires and cables:

- Use stranded wire. (Solid wire can be used for fixed service; it makes intermittent connections when you move it for maintenance.)
- Use 20 AWG (0.5 mm^2) thermocouple extension wire. Larger or smaller sizes may be difficult to install, may break easily or may cause intermittent connections.
- Use shielded wire. The electrical shield protects the signals and the CPC400 from electrical noise. Connect one end of the input and output wiring shield to earth ground.
- Use copper wire for all connections other than thermocouple sensor inputs.

Table 2.1 Cable Recommendations

Function	Mfr. P/N	No. of Wires	AWG	mm^2	Maximum Length
Analog Inputs	Belden 9154 Belden 8451	2 2	20 22	0.5 0.5	—
RTD Inputs	Belden 8772 Belden 9770	3 3	20 22	0.5 0.5	—
Thermocouple Inputs	T/C Ext. Wire	2	20	0.5	—
Control Outputs and Digital I/O	Belden 9539 Belden 9542 Ribbon Cable	9 20 50	24 24 22 to 14	0.2 0.2 0.5 to 2.5	—
Analog Outputs	Belden 9154 Belden 8451	2 2	20 22	0.5 0.5	—
Computer Communication: EIA/TIA-232, 422 or 485, or 20 mA	Belden 9729 Belden 9730 Belden 9842 Belden 9843 Belden 9184	4 6 4 6 4	24 24 24 24 22	0.2 0.2 0.2 0.2 0.5	4000 ft. (1219 m) 4000 ft. (1219 m) 6000 ft. (1829 m)

Noise Suppression

The CPC400 outputs are typically used to drive solid-state relays. These relays may in turn operate more inductive types of loads such as electromechanical relays, alarm horns and motor starters. Such devices may generate electromagnetic interference (EMI, or noise). If the controller is placed close to sources of EMI, it may not function correctly. Below are some tips on how to recognize and avoid problems with EMI.

For earth ground wire, use a large gauge and keep the length as short as possible. Additional shielding may be achieved by connecting a chassis ground strap from the panel to CPC400 case.

Symptoms of Noise

If your controller displays the following symptoms, suspect noise:

- The display screen blanks out and then reenergizes as if power had been turned off for a moment.
- The process variable value is incorrect on the controller display.

Noise may also damage the digital output circuit such that the digital outputs will not turn on. If the digital output circuit is damaged, return the controller to Watlow Anafaze for repair.

Avoiding Noise

To avoid or eliminate most RFI/EMI noise problems:

- Connect the CPC400 case to earth ground. The CPC400 system includes noise suppression circuitry. This circuitry requires proper grounding.
- Separate the 120V~ (ac) and higher power leads from the low-level input and output leads connected to the CPC400 series controller. Do not run the digital I/O or control output leads in bundles with ac wires.
- Where possible, use solid-state relays (SSRs) instead of electromechanical relays. If you must use electromechanical relays, avoid mounting them in the same panel as the CPC400 series equipment.
- If you must use electromechanical relays and you must place them in a panel with CPC400 series equipment, use a 0.01 microfarad capacitor rated at 1000V~ (ac) (or higher) in series with a 47 Ω, 0.5 watt resistor across the normally-open contacts of the relay load. This is known as a snubber network and can reduce the amount of electrical noise.
- You can use other voltage suppression devices, but they are not usually required. For instance, you can place a metal oxide varistor (MOV) rated at 130V~ (ac) for 120V~ (ac) control circuits across the load, which limits the peak ac voltage to about 180V~ (ac) (Watlow Anafaze part number 26-130210-00). You can also place a transorb (back-to-back zener diodes) across the digital output, which limits the digital output voltage.

Additional Recommendations for a Noise Immune System

We strongly recommended the following:

- Isolate outputs through solid-state relays, where possible.
- Isolate digital inputs from ground through solid-state relays. If this is not possible, then make sure the digital input is the only connection to earth ground other than the chassis ground.

Ground Loops

Ground loops occur when current passes from the process through the controller to ground. This can cause instrument errors or malfunctions.

The best way to avoid ground loops is to minimize unnecessary connections to ground. Do not connect any of the following terminals to each other or to earth ground:

- Power supply dc common
- TB1 terminals 5, 6, 11, 12 (analog common)
- TB1 terminal 17 (reference voltage common)
- TB1 terminals 23, 24 (communications common)
- TB2 terminal 2 (dc power common)

Power Connections

This section explains how to make power connections to the CPC400 and the TB50.

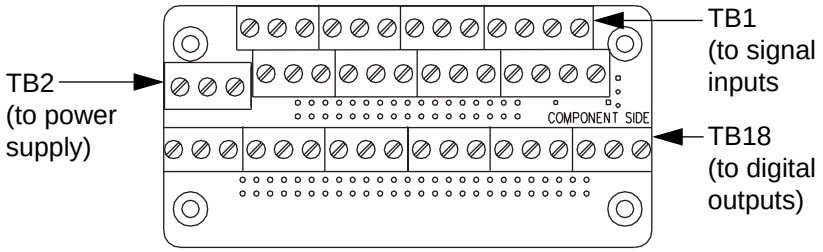


Figure 2.11 CPC400 Series Controller with TB18

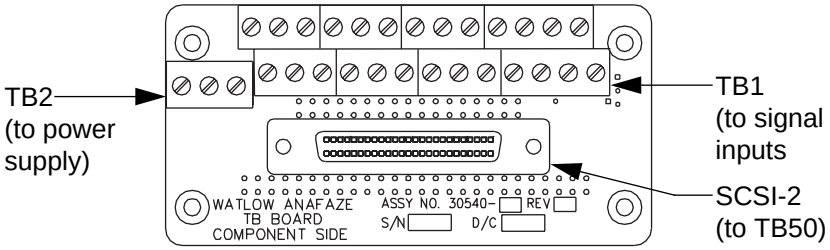


Figure 2.12 CPC400 Series Controller with TB50

Wiring the Power Supply

WARNING! ***Use a power supply with a Class 2 rating only. UL approval requires a Class 2 power supply.***

Connect power to the controller before any other connections, This allows you to ensure that the controller is working before any time is taken installing inputs and outputs.

Table 2.2 Power Connections

Function	Power Supply	CPC400 TB2
DC Power (Controller)	+12 to 24V⎓ (dc)	+
DC Common	12 to 24V⎓ (dc) Common	-
Earth Ground	Ground	⏚

1. Connect the dc common terminal on the power supply to the dc common (-) terminal on CPC400 TB2.
2. Connect the positive terminal on the power supply to the dc positive (+) terminal on CPC400 TB2.
3. If using an isolated dc output or another power supply to power the loads, connect the dc common of the supply powering the loads to the dc common of the supply powering the controller.
4. Use the ground connector on TB2 for chassis ground. This terminal is connected to the CPC400 chassis and must be connected to earth ground.
5. Connect 120/240V~ (ac) power to the power supply.

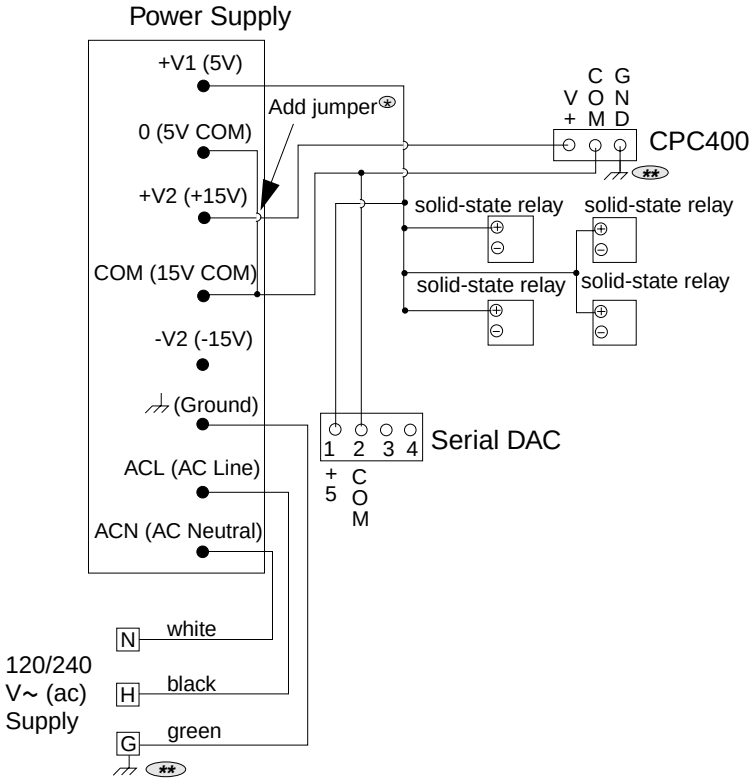
NOTE! ***Connect the dc common of the power supply used for loads to the dc common of the supply powering the controller. If the supplies are not referenced to one another, the controller's outputs will not be able to switch the loads.***

NOTE! ***When making screw terminal connections, tighten to 4.5 to 5.4 in.-lb. (0.5 to 0.6 Nm).***

CAUTION! ***Without proper grounding, the CPC400 may not operate properly or may be damaged.***

CAUTION! ***To prevent damage from incorrect connections, do not turn on the ac power before testing the connections as explained in Testing the System on page 26.***

NOTE! ***Do not connect the controller's dc common (COM) to earth ground ⏚. Doing so will defeat the noise protection circuitry, making measurements less stable.***



* If using 5V⎓ (dc) for outputs, jumper 5V common to 15V common.
** Connect ⏚ terminals to ac panel ground.

Figure 2.13 Power Connections with the CPC400 Power Supply

Connecting the TB50 to the CPC400

1. Connect the SCSI cable to the controller.
2. Connect the SCSI cable to the TB50.

Testing the System

This section explains how to test the controller after installation and prior to making field wiring connections.

TB50 or TB18 Test

Use this procedure to verify that the TB50 or TB18 is properly connected and supplied with power:

1. Turn on power to the CPC400. The display should first show *Calculating checksum*, and then show the single-loop display. If you do not see these displays, disconnect power and check wiring and power supply output.
2. Measure the +5V⎓ dc supply at the TB50 or TB18:
   a) Connect the voltmeter's common lead to TB50 terminal 3 or TB18 terminal 2.
   b) Connect the voltmeter's positive lead to TB50 or TB18 terminal 1. The voltage should be +4.75 to +5.25V⎓ dc.

Digital Output Test

Use this procedure to test the controller outputs before loads are connected. If using it at another time for troubleshooting, disconnect loads from outputs before testing.

1. Connect a 500 Ω to 100 kΩ resistor between TB50 or TB18 terminal 1 and a digital output terminal. See *Table 2.5 on page 37* for TB18 connections or *Table 2.6 on page 38* for TB50 connections.
2. Connect the voltmeter's positive lead to terminal 1 on the TB50 or TB18.
3. Connect the voltmeter's common lead to the digital output terminal.
4. Use the digital output test in the *I/O tests* menu to turn the digital output on and off (see *Test Digital Output 1 to 35 on page 132*). When the output is on, the output voltage should be less than 1 V. When the output is off, the output voltage should be between 4.75 and 5.25 V.

NOTE! ***By default, heat outputs are enabled. Only disabled outputs may be turned on using the manual I/O test. To test heat outputs, set the corresponding loop to manual mode 100 percent output. See Changing the Control Mode and Output Power on page 55.***

Digital Input Test

Use the following procedure to test digital inputs before connecting to field devices:

1. Disconnect any system wiring from the input to be tested.
2. Go to the *Digital inputs* test in the *I/O tests* menu. This test shows whether the digital inputs are off (open) or on (closed).
3. Attach a wire to the terminal of the digital input you want to test. See *Table 2.5 on page 37* for TB 18 connections or *Table 2.6 on page 38* for TB50 connections.
   a) When the wire is connected only to the digital input terminal, the digital input test should show that the input is off (open).
   b) When you connect the other end of the wire to the controller common (TB50 terminal 3 or TB18 terminal 2), the digital input test should show that the input is on (closed).

Sensor Wiring

This section describes how to properly connect thermocouples, RTDs, current and voltage inputs to the controller. The controller can accept any mix of available input types. Some input types require that special scaling resistors be installed (generally done by Watlow Anafaze before the controller is delivered).

All inputs are installed at the "CH" input connectors (TB1) at the back of the controller. The illustrations below show the connector locations for all CPC400 series controllers.

CAUTION! ***Never run input leads in bundles with high power wires or near other sources of EMI. This could inductively couple voltage onto the input leads and damage the controller, or could induce noise and cause poor measurement and control.***

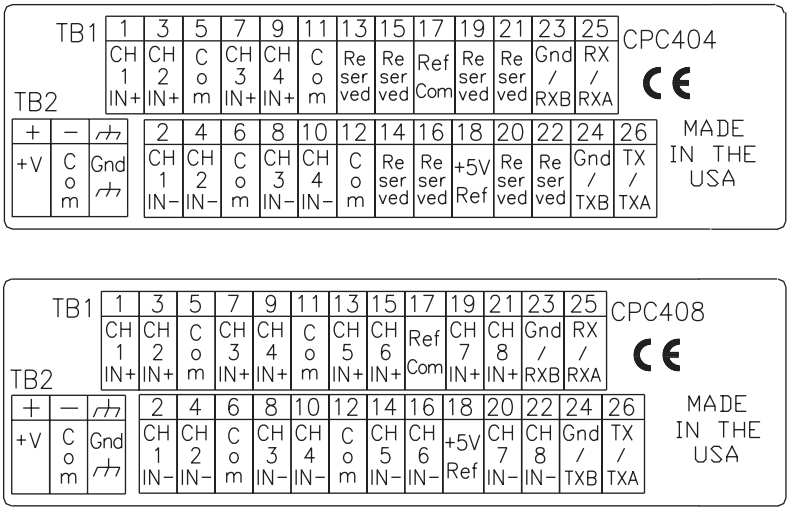


Figure 2.14 CPC400 Connector Locations

Input Wiring Recommendations

Use multicolored stranded shielded cable for analog inputs. Watlow Anafaze recommends that you use 20 AWG wire (0.5 mm^2). If the sensor manufacturer requires it, you can also use 24 or 22 AWG wiring (0.2 mm^2). Most inputs use a shielded twisted pair; some require a three-wire input.

The controller accepts the following inputs without any special scaling resistors:

- J, K, T, S, R, B and E thermocouples.
- Process inputs with ranges between -10 and +60 mV.

To avoid thermocouple open alarms on unused inputs, either set the *Input type* parameter to *skip* or jumper the input.

Thermocouple Connections

Connect the positive lead of the thermocouple to the IN+ terminal for one of the loops, and connect the negative lead to the corresponding IN- terminal.

Use 18 or 20 AWG (0.5 or 0.75 mm^2) for all thermocouple inputs. Most thermocouple wire is solid, unshielded wire. When using shielded wire, ground one end only.

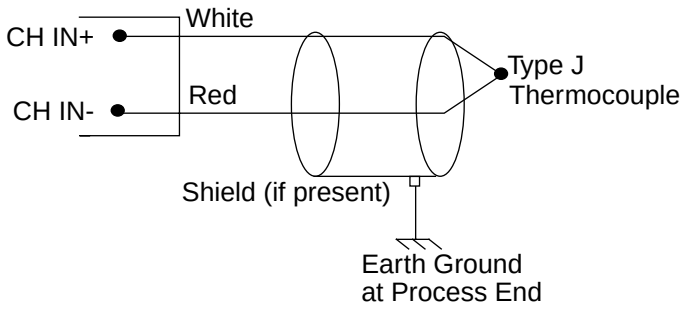


Figure 2.15 Thermocouple Connections

CAUTION!

Connect the earth ground terminal on TB2 to a good earth ground, but do not connect the analog common to earth ground. The CPC400 uses a floating analog common for sensor measurements. The noise protection circuits on the sensor inputs function correctly only if the controller is correctly installed. See Ground Loops on page 23.

RTD Input Connections

RTD input requires scaling resistors. Watlow Anafaze recommends that you use a 100 Ω, three-wire platinum RTD to prevent reading errors due to cable resistance. If you use a two-wire RTD, jumper the negative input to common. If you must use a four-wire RTD, leave the fourth wire unconnected.

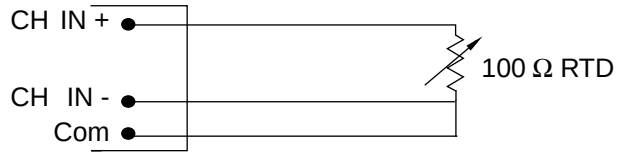


Figure 2.16 RTD Connections

Reference Voltage Terminals

The +5V Ref and Ref Com terminals are provided to power external bridge circuits for special sensors. Do not connect any other type of device to these terminals.

Voltage Input Connections

Voltage input requires scaling resistors. Special input resistors installed at Watlow Anafaze divide analog input voltages such that the controller sees a -10 to 60 mV signal on the loop.

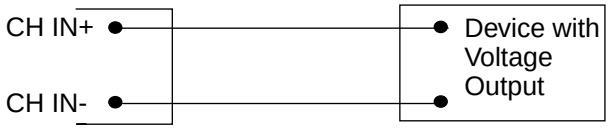


Figure 2.17 Voltage Signal Connections

Current Input Connections

Current input requires scaling resistors. Special input resistors installed at Watlow Anafaze for analog current signals are such that the controller sees a -10 to 60 mV signal across its inputs for the loop.

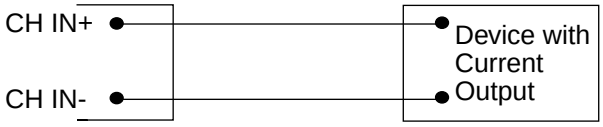


Figure 2.18 Current Signal Connections

Pulse Input Connections

The CPC400 can accept a pulse input up to 2000 Hz from a device such as an encoder. The frequency of this input is scaled with user-configured parameters; see *Setting Up a Process or Pulse Input on page 58*. This scaled value is the process variable for loop 5 on a CPC404, or loop 9 on a CPC408.

The CPC400 can accommodate encoder signals up to 24V⎓ (dc) using a voltage divider or can power encoders with the 5V⎓ (dc) from the TB50 or TB18. The following figures show how to connect encoders. A pull-up resistor in the CPC400 allows open collector inputs to be used.

NOTE! ***If the signal on the pulse input exceeds 10kHz the controller's operation may be disrupted. Do not connect the pulse input to a signal source that may exceed 10kHz.***

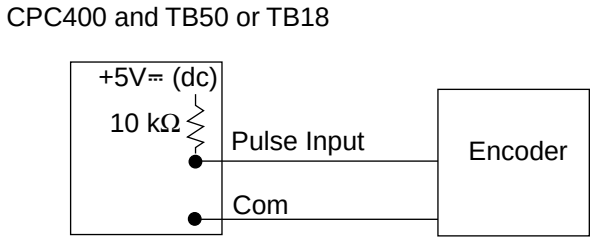


Figure 2.19 Encoder with 5V⎓ (dc) TTL Signal

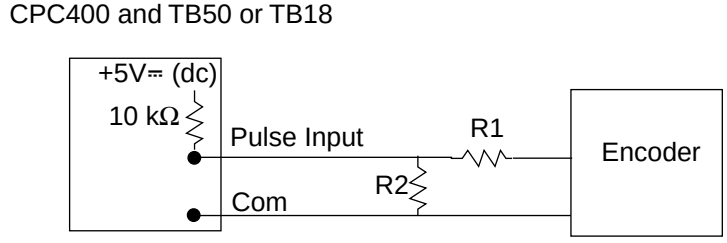


Figure 2.20 Encoder Input with Voltage Divider

For encoders with signals greater than 5V⎓ (dc), use a voltage divider to drop the voltage to 5 volts at the input. Use appropriate values for R_1 and R_2 depending on the encoder excitation voltage. Do not exceed the specific current load on the encoder.

Wiring Control and Digital I/O

This section describes how to wire and configure the control outputs for the CPC400 series controller. The CPC400 provides dual control outputs for each loop. These outputs can be enabled or disabled, and are connected through a TB50 or TB18.

NOTE! ***Control outputs are connected to controller common when the control output is on. If you connect external devices that may have a low side at a voltage other than controller ground, you may create ground loops. To prevent ground loops, use isolated solid-state relays and isolate the control device inputs.***

Output Wiring Recommendations

When wiring output devices, use multicolored, stranded, shielded cable for analog outputs and digital outputs connected to panel-mounted solid-state relays.

- Analog outputs usually use a twisted pair.
- Digital outputs usually have 9 to 20 conductors, depending on wiring technique.

Cable Tie Wraps

After you wire outputs to the TB50, install the cable tie wraps to reduce strain on the connectors. Each row of terminals has a cable tie wrap hole at one end. Thread the cable tie wrap through the cable tie wrap hole. Then, wrap the cable tie wrap around the wires attached to that terminal block.

Digital Outputs

The CPC400 provides dual control outputs for up to eight loops. By default, heat outputs are enabled and cool outputs are disabled. If the heat or cool output is disabled for a loop, then the output is available for alarms or programmable logic. The CPU watchdog timer output can be used to monitor the state of the controller; see *CPU Watchdog Timer on page 35*.

Table 2.3 Digital Output States and Values Stored in the Controller

State	Value[1]	Description
Off	0	Open circuit
On	1	Sinking current to controller common

[1] Read and write these values through serial communications and LogicPro programs.

All digital outputs sink current to controller common when on. The load may powered by the 5V⎓ (dc) supplied by the controller at the TB50, or by an external power supply. When using an external power supply, bear in mind:

- The CPC400 power supply available from Watlow Anafaze includes a 5V⎓ (dc) supply. When using it to supply output loads, connect the 5V⎓ (dc) common to the 15V⎓ (dc) common at the power supply.
- Do not exceed +24 volts.
- If you connect the external load to earth ground, or if you cannot connect it as shown in *Figure 2.21*, then use a solid-state relay.

The outputs conduct current when they are on. The maximum current sink capability is 60 mA at 24V⎓ (dc). The outputs cannot "source" current to a load.

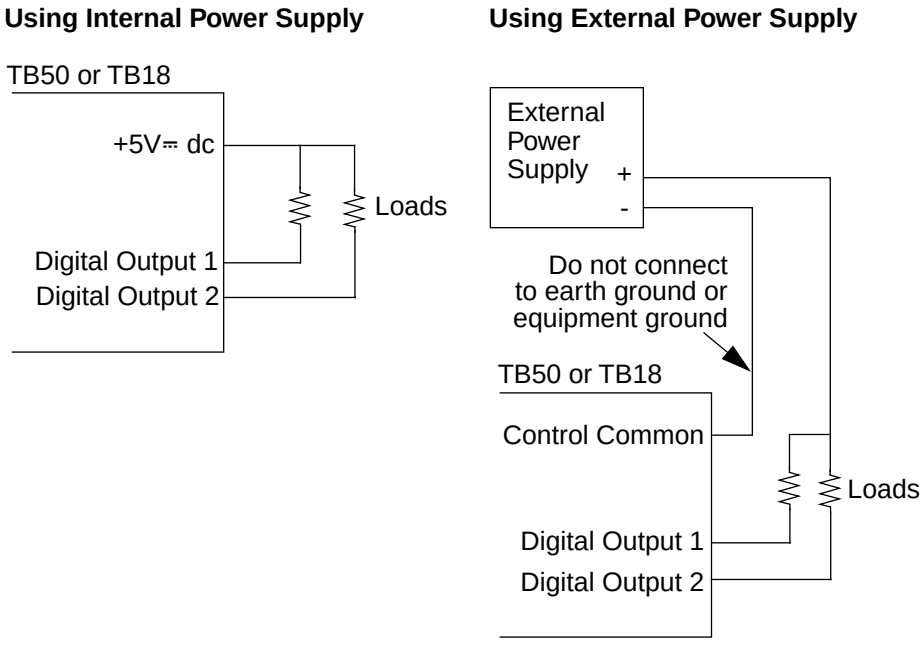


Figure 2.21 Digital Output Wiring

Configuring Outputs

As you choose outputs for control and alarms, bear in mind the following points:

- You can enable or disable the control outputs. By default, heat outputs are enabled and cool outputs are disabled.
- You can program each control output individually for on/off, time proportioning, distributed zero-crossing or Serial DAC control.
- You can individually program each control output for direct or reverse action.
- Alarm outputs other than the global alarm are non-latching. See *Global Alarm on page 67*.
- Alarms can be suppressed during process start up and for preprogrammed durations. See *Power Up Alarm Delay on page 100*.
- Alarm outputs can be configured, as a group, to sink to output during an alarm or stop current flow during an alarm. See *Digital Output Alarm Polarity on page 103*.

Control and Alarm Output Connections

Typically control and alarm outputs use external optically-isolated solid-state relays (SSRs). SSRs accept a 3 to 32V⎓ (dc) input for control, and some can switch up to 100 Amps at 480V~ (ac). For larger currents, use silicon control rectifier (SCR) power controllers up to 1000 Amps at 120 to 600V~ (ac). You can also use SCRs and a Serial DAC for phase-angle fired control.

The 34 control and alarm outputs are open collector outputs referenced in the CPC400's common. Each output sinks up to 60 mAdc to the controller common when on.

NOTE! ***Control outputs are sink outputs. They sink current when the output is on. Connect them to the negative side of solid-state relays.***

Figure 2.22 shows sample heat, cool and alarm output connections.

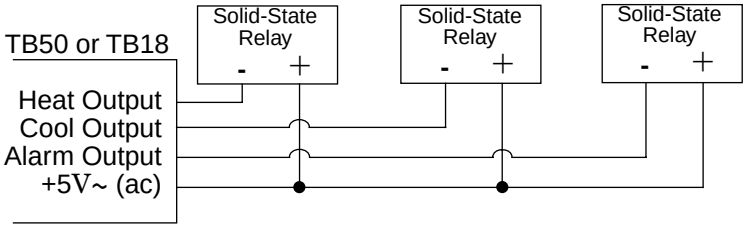


Figure 2.22 Sample Heat, Cool and Alarm Output Connections

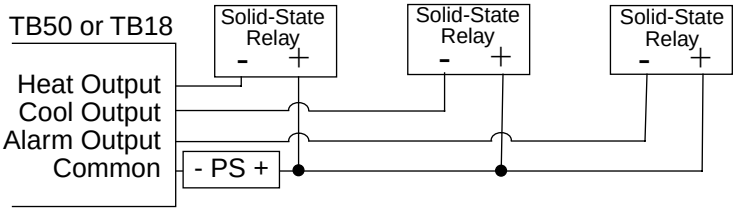


Figure 2.23 Output Connections Using External Power Supply

CPU Watchdog Timer

The CPU watchdog timer constantly monitors the microprocessor. It is a sink output located on TB50 terminal 6 or TB18 terminal 3. The output can be connected to an external circuit or device to monitor whether the controller is powered and operational. Do not exceed the 5V⎓ (dc), 10 mAdc rating for the watchdog output. The output is on (low) when the microprocessor is operating; when it stops operating, the output goes off (high).

Figure 2.24 and *Figure 2.25* show the recommended circuit for the watchdog timer output for the TB50 and the TB18.

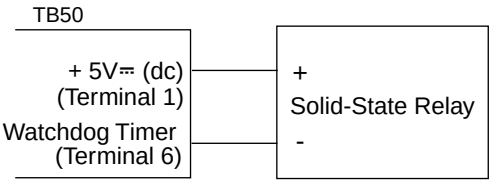


Figure 2.24 TB50 Watchdog Timer Output

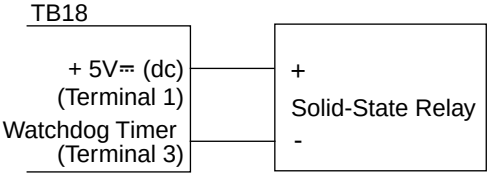


Figure 2.25 TB18 Watchdog Timer Output

Digital Inputs

All digital inputs are transistor-transistor logic (TTL) level inputs referenced to controller common and the internal +5V power supply of the CPC400.

When an input is connected to the controller common, the input is considered on. Otherwise, the input is considered off. Most features that use the digital inputs can be user-configured to activate when an input is either on or off.

In the off state, internal 10 kΩ resistors pull the digital inputs high to 5V⎓ (dc) with respect to the controller common.

Table 2.4 Digital Input States and Values Stored in the Controller

State	Value[1]	Description
Off	0	Open circuit
On	1	Digital input connected to controller common

[1] Read these values through serial communications and LogicPro programs.

External Switching Device

To ensure that the inputs are reliably switched, use a switching device with the appropriate impedances in the on and off states and do not connect the inputs to external power sources.

When off, the switching device must provide an impedance of at least 11 kΩ to ensure that the voltage will rise to greater than 3.7V⎓ (dc). When on, the switch must provide not more than 1 kΩ impedance to ensure the voltage drops below 1.3V⎓ (dc).

To install a switch as a digital input, connect one lead to the common terminal on the TB50 (terminals 3 and 4) or TB18 (terminal 2). Connect the other lead to the desired digital input terminal on the TB50 (terminals 43 to 50) or TB18 (terminals 16 to 18).

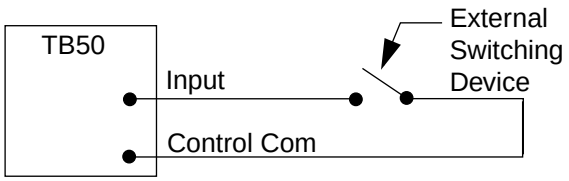


Figure 2.26 Wiring Digital Inputs

Functions Activated by Digital Inputs

Use digital inputs to activate the following functions:

- Load a job that is stored in controller memory. See *BCD Job Load on page 97*.
- Change all loops to manual mode at specified output levels. See *Mode Override on page 99*.
- Enable thermocouple short detection. See *Thermocouple Short Alarm on page 101*.
- Restore automatic control after a failed sensor has been repaired. See *Restore Automatic Mode on page 114*.

TB18 Connections

Table 2.5 TB18 Connections

		Control Output[1]	
Terminal	**Function**	**CPC404**	**CPC408**
1	+5V⎓ (dc)		
2	CTRL COM		
3	Watchdog timer		
4	Global alarm		
5	Output 1	Loop 1 heat	Loop 1 heat
6	Output 2	Loop 2 heat	Loop 2 heat
7	Output 3	Loop 3 heat	Loop 3 heat
8	Output 4	Loop 4 heat	Loop 4 heat
9	Output 5	Pulse loop heat	Loop 5 heat
10	Output 6	Loop 1 cool	Loop 6 heat
11	Output 7	Loop 2 cool	Loop 7 heat
12	Output 8	Loop 3 cool	Loop 8 heat
13	Output 9	Loop 4 cool	Pulse loop heat
14	Output 10	Pulse loop cool	Loop 1 cool
15	Output 34[2]	Serial DAC clock	Serial DAC clock
16	Input 1		
17	Input 2		
18	Input 3/Pulse input		

[1] The indicated outputs are dedicated for control when enabled in the loop setup. If one or both of the outputs are disabled for a loop, then the corresponding digital outputs become available for alarms or programmable logic.

[2] If you install a Watlow Anafaze Serial DAC, the CPC400 series controller uses digital output 34 for a clock line. You cannot use output 34 for anything else if a Serial DAC is installed.

TB50 Connections

Table 2.6 TB50 Connections

		Control Output[1]				Control Output[1]	
Terminal	**Function**	**CPC408**	**CPC404**	**Terminal**	**Function**	**CPC408**	**CPC404**
1	+5V⎓ (dc)			2	+5V⎓ (dc)		
3	CTRL COM			4	CTRL COM		
5	Not Used			6	Watchdog Timer		
7	Pulse Input			8	Global Alarm		
9	Output 1	Loop 1 heat	Loop 1 heat	10	Output 34[2]		
11	Output 2	Loop 2 heat	Loop 2 heat	12	Output 33		
13	Output 3	Loop 3 heat	Loop 3 heat	14	Output 32		
15	Output 4	Loop 4 heat	Loop 4 heat	16	Output 31		
17	Output 5	Loop 5 heat	Pulse loop heat	18	Output 30		
19	Output 6	Loop 6 heat	Loop 1 cool	20	Output 29		
21	Output 7	Loop 7 heat	Loop 2 cool	22	Output 28		
23	Output 8	Loop 8 heat	Loop 3 cool	24	Output 27		
25	Output 9	Pulse loop heat	Loop 4 cool	26	Output 26		
27	Output 10	Loop 1 cool	Pulse loop cool	28	Output 25		
29	Output 11	Loop 2 cool		30	Output 24		
31	Output 12	Loop 3 cool		32	Output 23		
33	Output 13	Loop 4 cool		34	Output 22		
35	Output 14	Loop 5 cool		36	Output 21		
37	Output 15	Loop 6 cool		38	Output 20		
39	Output 16	Loop 7 cool		40	Output 19		
41	Output 17	Loop 8 cool		42	Output 18	Pulse loop cool	
43	Input 1			44	Input 2		
45	Input 3			46	Input 4		
47	Input 5			48	Input 6		
49	Input 7			50	Input 8		

[1] The indicated outputs are dedicated for control when enabled in the loop setup. If one or both of a loop's outputs are disabled, the corresponding digital outputs become available for alarms or programmable logic.

[2] If you install a Watlow Anafaze Serial DAC, the CPC400 uses digital output 34 (terminal 10) for a clock line. You cannot use output 34 for anything else if a Serial DAC is installed.

Analog Outputs

Analog outputs can be provided by using a Dual DAC or Serial DAC module to convert the open collector outputs from the controller. Use multicolored stranded shielded cable for analog outputs. Analog outputs generally use a twisted pair wiring. The following sections describe how to connect the Dual DAC and Serial DAC modules to power the controller outputs and the load.

Wiring the Dual DAC

A Dual DAC module includes two identical circuits. Each can convert a distributed zero cross (DZC) signal from the controller to a voltage or current signal. Watlow Anafaze strongly recommends using a power supply separate from the controller supply to power the Dual DAC. Using a separate power supply isolates the controller's digital logic circuits and analog measurement circuits from the frequently noisy devices that take the analog signal from the Dual DAC.

Several Dual DAC modules may be powered by one power supply. Consult the Specifications chapter for the Dual DAC's power requirements. Also note in the specifications that the Dual DAC does not carry the same industry approvals as the Serial DAC.

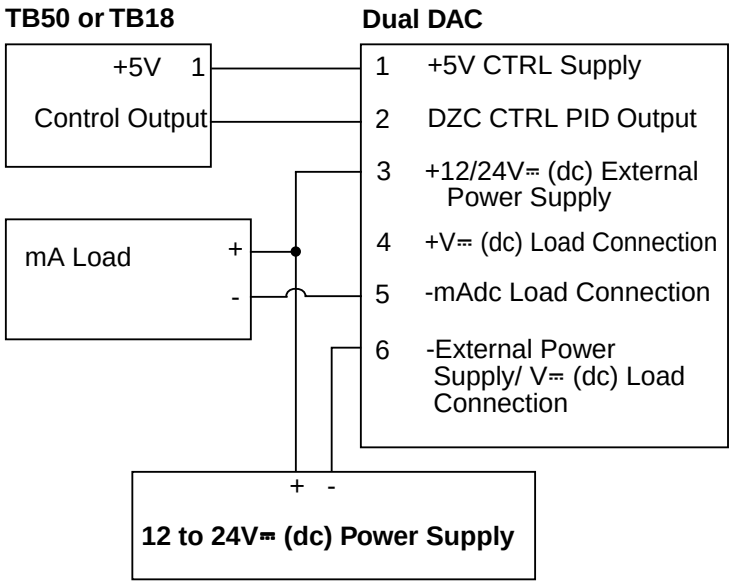


Figure 2.27 Dual DAC with Current Output

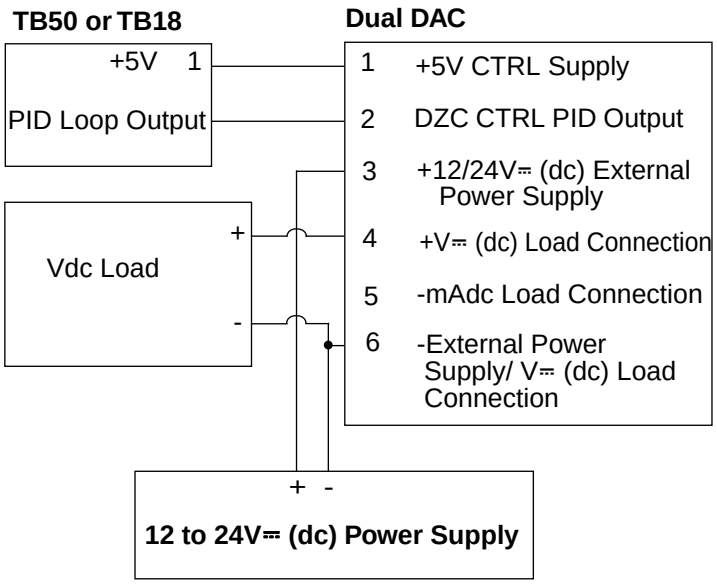


Figure 2.28 Dual DAC with Voltage Output

Wiring the Serial DAC

The Serial DAC provides a robust analog output signal. The module converts the proprietary Serial DAC signal from the controller's open collector output in conjunction with the clock signal to an analog current or voltage. See *Figure 2.29* for wiring. The Serial DAC is user-configurable for voltage or current output through firmware configuration. See *Configuring Serial DAC Outputs on page 162*.

The Serial DAC optically isolates the controller's control output from the load. When a single Serial DAC is used, it may be powered by the 5V⎓ (dc) found on the TB50 or by an external power supply referenced to the controller's power supply. When using multiple Serial DACs, the controller cannot provide sufficient current; use the 5V⎓ (dc) output from the CPC400 power supply.

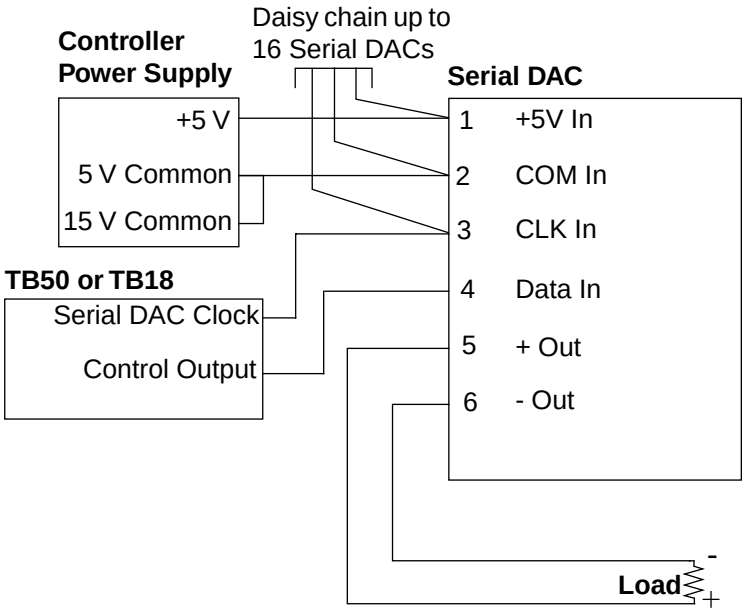


Figure 2.29 Single/Multiple Serial DACs

Serial Communications

The CPC400 series controllers are factory-configured for EIA/TIA-232 communications unless otherwise specified when purchased. However, the communications are jumper-selectable, so you can switch between EIA/TIA-232 and EIA/TIA-485. See *Changing the Hardware Communications Protocol on page 157*.

EIA/TIA-232 Interface

EIA/TIA-232 provides communication to the serial port of an IBM PC or compatible computer. It is used for single-controller installations where the cable length does not exceed 50 feet (15 m).

The EIA/TIA-232 interface is a standard three-wire interface. Table 2.7 shows EIA/TIA-232 connections for 25-pin and 9-pin connectors or cables that are supplied by the factory.

EIA/TIA-232 may be used to connect a computer through a 232-to-485 converter to an EIA/TIA-485 communications network with up to 32 CPC400 controllers.

Table 2.7 EIA/TIA-232 Connections

Wire Color	CPC400 TB1	DB 9 Connector	DB 25 Connector
White	TX Pin 26	RX Pin 2	RX Pin 3
Red	RX Pin 25	TX Pin 3	TX Pin 2
Black	GND Pin 23	GND Pin 5	GND Pin 7
Green	GND Pin 24	N/U Pin 9	N/U Pin 22
Shield	N/C	GND Pin 5	GND Pin 7

Jumpers in EIA/TIA-232 Connectors

Some software programs and some operator interface terminals require a clear to send (CTS) signal in response to their request to send (RTS) signal, or a data set ready (DSR) in response to their data terminal ready (DTR). The CPC400 is not configured to receive or transmit these signals. To use such software with the CPC400, jumper the RTS to the CTS and the DTR to the DSR in the DB connector. Table 2.8 lists the standard pin assignments for DB-9 and DB-25 connectors.

Table 2.8 RTS/CTS and DSR/DTR Pins in DB-9 and DB-25 Connectors

	DB-9	DB-25
RTS	7	4
CTS	8	5
DTR	4	20
DSR	6	6

Cables manufactured by Watlow Anafaze for EIA/TIA-232 communications include these jumpers. Neither WATVIEW nor LogicPro software requires these jumpers.

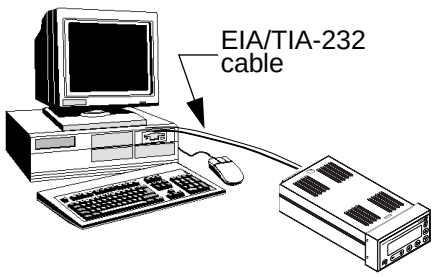


Figure 2.30 Connecting One CPC400 to a Computer Using EIA/TIA-232

EIA/TIA-485 Interface

To communicate with more than one CPC400 series controller on a controller network, or to use communication cable lengths greater than 50 feet (15 m) from PC to controller, you must use EIA/TIA-485 communications.

When using EIA/TIA-485 communications, you must attach a 232-to-485 converter to the computer. *Figure 2.31* and *Figure 2.32* show the recommended system wiring.

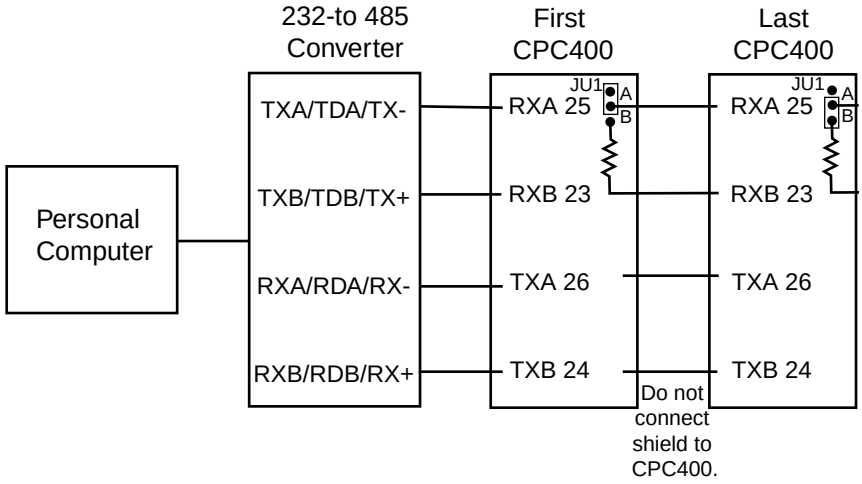


Figure 2.31 Four-Wire EIA/TIA-485 Wiring

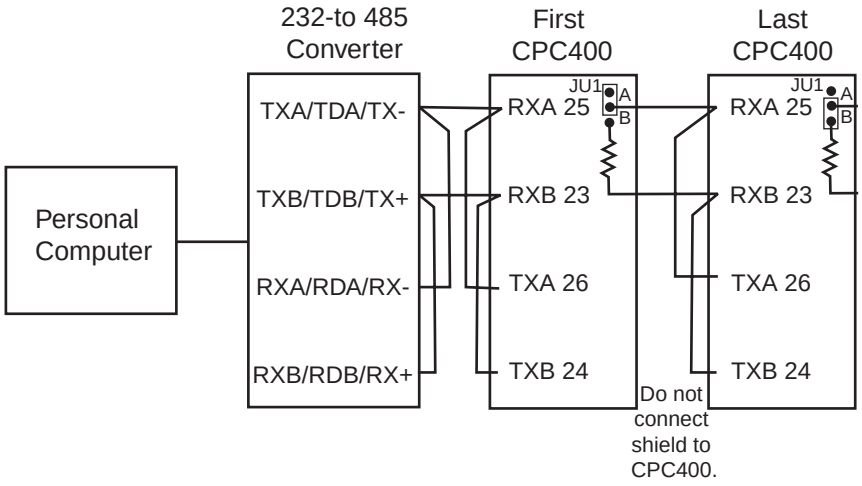


Figure 2.32 Two-Wire EIA/TIA-485 Wiring

Cable Recommendations

Watlow Anafaze recommends Belden 9843 cable or its equivalent. This cable includes three 24 AWG (0.2 mm^2), shielded twisted pairs. It should carry signals of up to 19200 baud with acceptable losses for up to 4000 feet (1220 m).

EIA/TIA-485 Network Connections

Watlow Anafaze recommends that you use a single daisy chain configuration rather than spurs. Run a twisted-pair cable from the host or converter to the first CPC400, and from that point run a second cable to the next CPC400, and so on. See *Figure 2.33*.

If necessary for servicing, instead of connecting each controller directly to the next, install a terminal strip or connector as close as possible to each CPC400, run a communications cable from one terminal strip to the next and connect the controllers to the bus with short lengths of cable.

To avoid unacceptable interference, use less than 10 feet (3 m) of cable from the terminal or connector to the CPC400 serial port.

Refer to *Termination on page 45* for more on terminating resistors.

Connect the shield drain to earth ground only at the computer or host end.

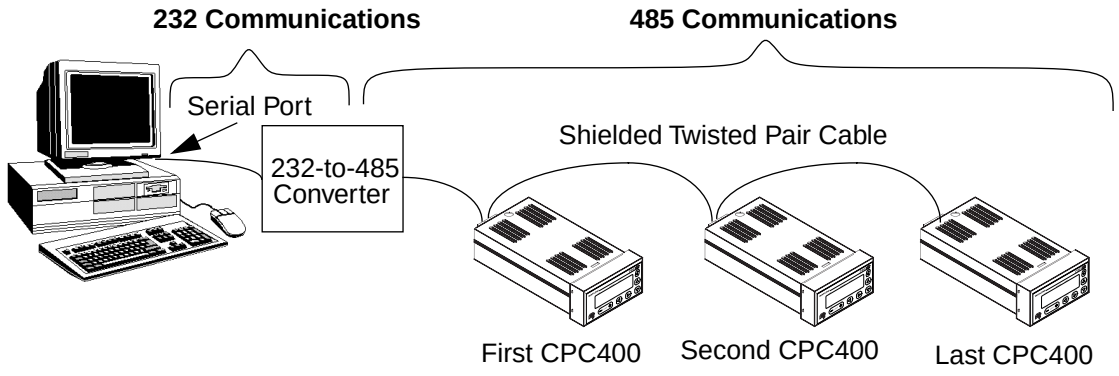


Figure 2.33 Recommended System Connections

Signal Common

For usual installations, do not connect the dc commons of the controllers together or to the converter or host device.

Termination

For EIA/TIA-485 signals to be transmitted properly, each pair must be properly terminated. The value of the termination resistor should be equal to the impedance of the communications cable used. Values are typically 150 to 200 Ω.

The receive lines at the converter or host device should be terminated in the converter, the connector to the host device or the device itself. Typically the converter documentation provides instructions for termination.

Use a terminating resistor on the receive lines on the last controller on the 485 line. Set jumper JU1 in position B to connect a 200 Ω resistor across the receive lines. See *Changing the Hardware Communications Protocol on page 157*.

3

Operation and Setup

This chapter explains how to use the keypad and display to operate the controller. This chapter also explains the basic concepts that you need to understand to set up and operate the controller.

General Navigation Map

The normal display on the CPC400 is the loop display. *Figure 3.1* shows how to navigate from the loop display to other displays, menus and parameters.

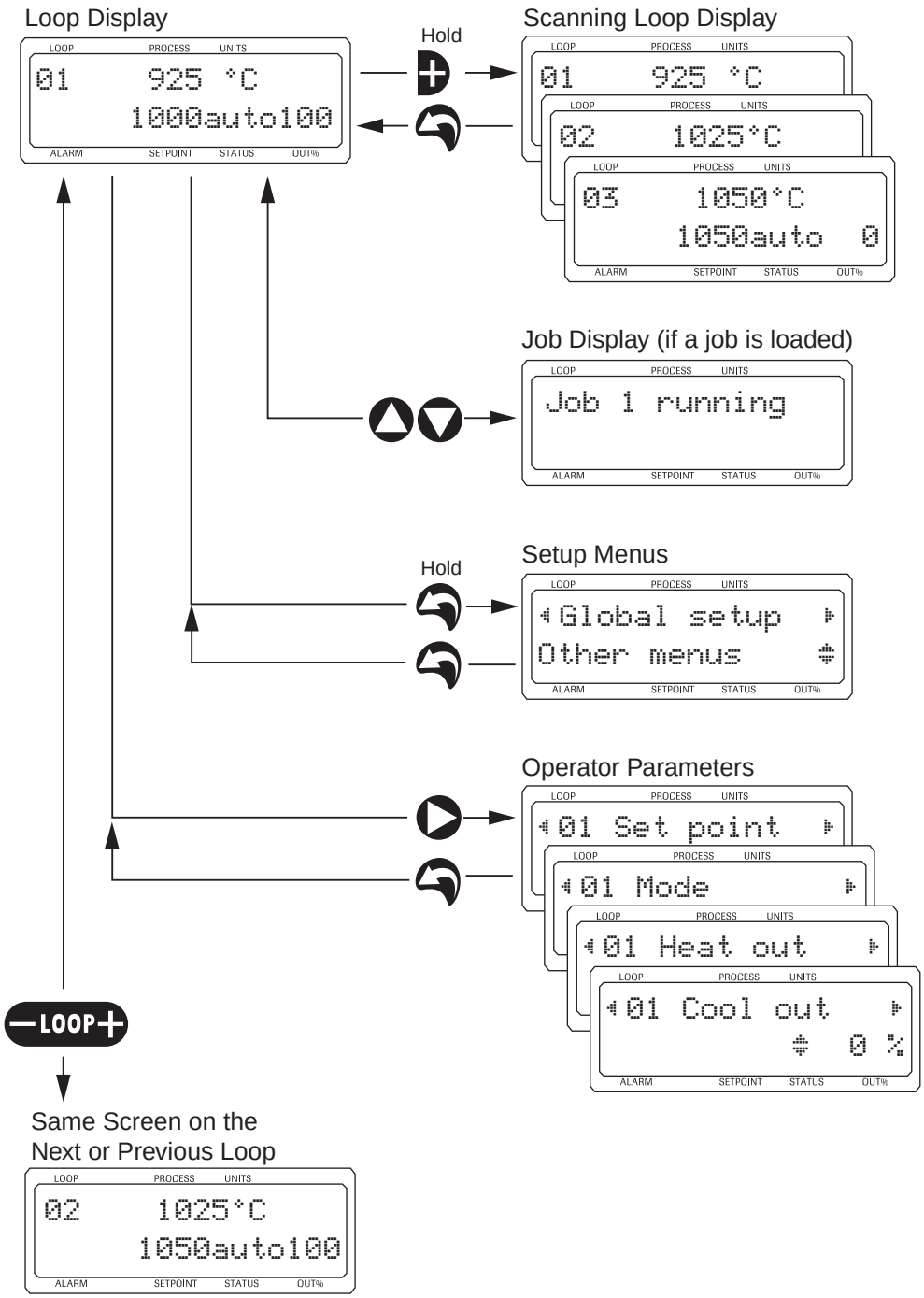
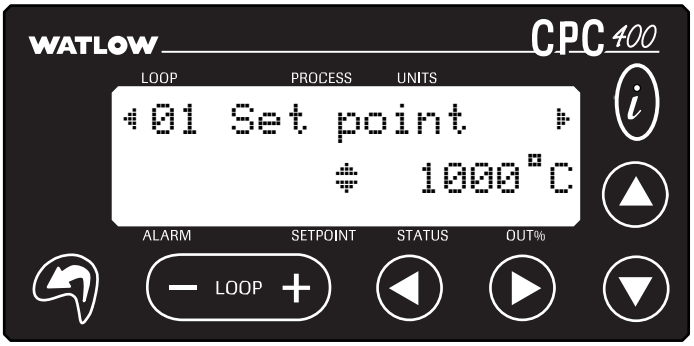


Figure 3.1 General Navigation Map

Keypad



Key	Description
	Access the setup menus (press and hold for 3 seconds). Cancel a change without saving. Escape from a parameter to a top-level setup menu. Escape from a setup menu to the loop display or job display. Acknowledge an alarm.
	Toggle between the loop display and job display (if a job is loaded). Edit a parameter value. Scroll through the top-level setup menus.
	Toggle between the loop display and job display (if a job is loaded). Edit a parameter value. Scroll through the top-level setup menus. Clear RAM and set all parameters to defaults (hold during power up).
	Save a change and go to the previous parameter.
	Access the operator parameters (from the loop display). Save a change and go to the next parameter.
LOOP	Go to a different loop. Save a change and go to a different loop. Go to the scanning loop display (hold + for 3 seconds).
	Get more information about the current screen.

Figure 3.2 Keypad Navigation

Displays

Loop Display

The loop display shows detailed information about a loop.

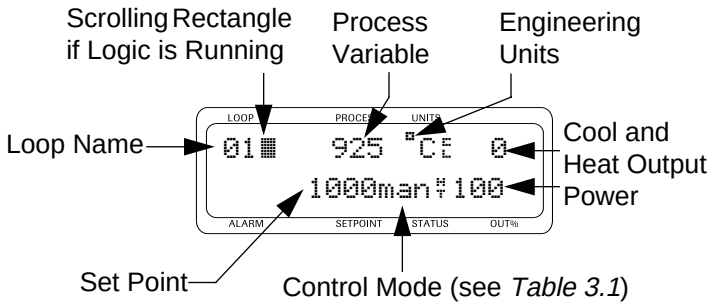


Figure 3.3 Loop Display

The control modes are described in *Table 3.1*.

Table 3.1 Control Modes on the Loop Display

Display Value	Description
man	The loop is in manual control. One or both outputs are enabled.
auto	The loop is in automatic control. Only one output (heat or cool) is enabled.
heat	The heat and cool outputs are enabled. The loop is in automatic control and heating.
cool	The heat and cool outputs are enabled. The loop is in automatic control and cooling.
tun	The loop is in the initial autotune mode. Blinks when tuning.
adpt	The loop is in adaptive control mode. Only one output (heat or cool) is enabled. Blinks when outside the tune band.
HtAd	Both the heat and the cool outputs are enabled. The loop is in adaptive control and heating. Blinks when outside the tune band.
ClAd	Both the heat and the cool outputs are enabled. The loop is in adaptive control and cooling. Blinks when outside the tune band.
(blank)	The heat and cool outputs are both disabled.

NOTE! ***If the input type for a loop is set to "skip," the loop display will be blank for that loop.***

The scanning loop display sequentially displays the information for each loop. The data for each loop displays for one second. To activate the scanning loop display, go to the loop display, then press and hold the + side of the LOOP key for three seconds. To exit the scanning mode, press any key.

Alarm Displays

If an alarm condition occurs, the controller displays an alarm code or alarm message.

Two-Character Alarm Codes

If a process, deviation or failed sensor alarm occurs, a two-character alarm code appears in the lower left corner of the loop display.

The alarm code blinks and you cannot change the display until the alarm has been acknowledged. After the alarm is acknowledged, the alarm code stops blinking. The alarm code remains on the display until the condition that caused the alarm is corrected.

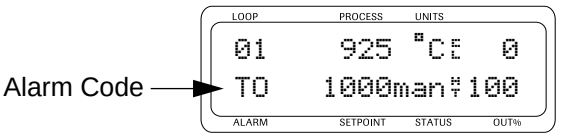


Figure 3.4 Loop Display with Alarm Code

For more information about alarms, see *Setting Up Alarms on page 63* and *Process Alarms on page 65*.

Failed Sensor Alarm Messages

If the alarm is for a failed sensor, an alarm message appears in the first line of the loop display, as shown in *Figure 3.5*.

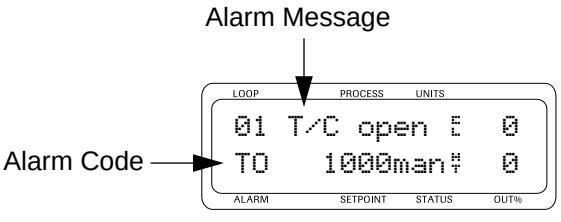


Figure 3.5 Display for Failed Sensor Alarm

Table 3.2 describes the alarm codes and messages for process alarms and failed sensor alarms.

Table 3.2 Alarm Codes and Messages for Process and Failed Sensor Alarms

Alarm Code	Alarm Message	Description
AH	(No message)	Alarm high. See *Alarm High and Alarm Low on page 66*.
AL	(No message)	Alarm low. See *Alarm High and Alarm Low on page 66*.
HD	(No message)	High deviation alarm. See *Deviation Alarms on page 66*.
LD	(No message)	Low deviation alarm. See *Deviation Alarms on page 66*.
TO	T/C open	Thermocouple open. See *Thermocouple Open Alarm on page 64*.
TR	T/C reversed	Thermocouple reversed. See *Thermocouple Reversed Alarm on page 64*.
TS	T/C shorted	Thermocouple shorted. See *Thermocouple Short Alarm on page 64*.
RO	RTD open	RTD open. See *RTD Open or RTD Shorted Alarm on page 65*.
RS	RTD shorted	RTD shorted. See *RTD Open or RTD Shorted Alarm on page 65*.
AW	(No message)	Ambient Warning. Controller's ambient temperature has exceeded operating limits by less than 5°C

For details about the condition that causes each alarm, see *Setting Up Alarms on page 63*.

How to Acknowledge an Alarm

To acknowledge a process alarm or failed sensor alarm, press ↶. If there are other loops with alarm conditions, the alarm display switches to the next loop that has an alarm. Acknowledge all alarms to clear the global alarm digital output.

The keypad and display will not work for anything else until you acknowledge each alarm. The alarm code or message persists as long as the alarm condition exists.

System Alarm Messages

If a system alarm occurs, the alarm message replaces the entire display. The message persists until the condition is corrected.

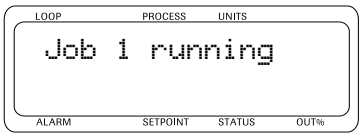
Table 3.3 describes system alarm messages. For more information, see the *Troubleshooting and Reconfiguring* chapter.

Table 3.3 System Alarm Messages

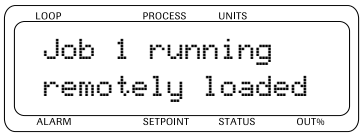
Message	Description
Low power	The power supply has failed. See *Low Power on page 145*.
Battery dead	The RAM battery in the CPC400 is not functioning correctly, and stored data has been corrupted. See *Battery Dead on page 145*.
H/W failure: Ambient	The temperature around the controller is outside of the acceptable range of 0 to 50°C. See *If the controller has failed, it may have been damaged by excessive voltage. Before replacing the controller, troubleshoot for high ac voltage on sensors or outputs. See Checking Analog Inputs on page 148. on page 146*.
H/W failure: Gain	Hardware failed because of excessive voltage on inputs. See *H/W Failure: Gain or Offset on page 146*.
H/W failure: Offset	

Job Display

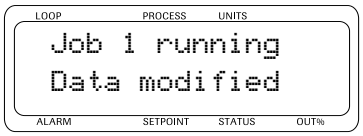
The job display appears if you load a job from memory. If you load a job using the *Load setup from job* parameter, the job display shows the following screen:



If the job was loaded using digital inputs, the display shows this screen:



If parameters are modified while the job is running, the display shows this screen:



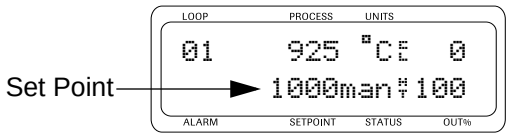
To toggle between the job display and the loop display, press ▲ or ▼.

Changing the Set Point

How to Manually Change the Set Point

Start at the loop display and follow these steps:

1. Press LOOP to choose the appropriate loop.
2. Press ▶. The *Set point* parameter should appear. If nothing happens, the keypad may be locked; see *Keypad Lock on page 101*. Also, the *Set point* parameter is not available if cascade control or ratio control is enabled on the loop.
3. Press ▲ or ▼ to adjust the set point value.
4. Press ◀ to save the value and return to the loop display, *or* press LOOP to save the value and switch to the set point for another loop, *or* press ↩ to cancel changes.
5. On the loop display, the new set point value is shown on the second line.



Other Methods of Changing the Set Point

You can use other methods to change the set point:

- **Cascade Control:** Use the output of one loop to adjust the set point of another loop. See *Setting Up Cascade Control on page 69*.
- **Ratio Control:** Use the process variable of one loop, multiplied by a ratio, as the set point of another loop. See *Setting Up Ratio Control on page 73*.
- **Differential Control:** Use the process variable of one loop, plus an offset value, as the set point of another loop. See *Setting Up Differential Control on page 75*.
- **Remote Analog Set Point:** Use an external device such as a PLC to control the set point. See *Setting Up Remote Analog Set Point on page 76*.
- **Serial Communications:** Use a computer program or operator interface panel to change the set point. See the Appendix: Modbus RTU.
- **Logic Program:** Use a LogicPro logic program to control the set point. The logic program overrides set point values that are set by other means. See the *LogicPro User's Guide*.

Changing the Control Mode and Output Power

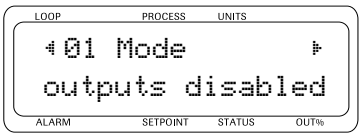
The CPC400 has four control modes:

- **Auto:** The controller automatically adjusts the output power according to the set point, process variable and other control parameters.
- **Manual:** The operator sets the output power level.
- **Tune:** The controller calculates the best PID settings for optimum control. For more information, see *Auto-tuning on page 62*. This mode has no effect with on/off control.
- **Adapt:** The controller automatically adjusts the output power as with Auto mode, and it updates the control parameters as needed to keep the tuning optimized. This mode has no effect with on/off control.

To change the control mode and output power level, start at the loop display and do the following:

1. Press LOOP to choose the appropriate loop.
2. Press ▶ twice. The *Mode* parameter should appear. (If nothing happens, the keypad may be locked; see *Keypad Lock on page 101*).

NOTE! ***If the heat and cool outputs are disabled on this loop, the Mode parameter is not available. Instead, this message appears:***



3. Press ▲ or ▼ to choose a control mode.
4. Press ▶ to save the new value, or press ↩ to cancel the change.
5. If you chose *manual* mode, then the next parameter is the *Heat output* or *Cool output* parameter. Use these parameters to set the heat and cool output power levels, then press ▶ to save.
6. You should be back at the loop display. The control mode is shown on the second line of the loop display; see *Table 3.1 on page 50*.

Accessing and Navigating the Setup Menus

Use the setup menus to configure the controller. For a list of all setup menus and parameters, refer to *Figure 5.2 on page 95*.

How to Access the Setup Menus

To access the setup menus, press and hold ↩ for three seconds, until the *Global setup* menu appears.

To prevent unauthorized personnel from accessing setup parameters, the controller reverts to the regular display if you do not press any keys for three minutes.

How to Edit a Setup Parameter

To edit a setup parameter, go to the appropriate setup menu, go to the parameter, then edit the value:

1. Press and hold ↩ for three seconds to access the setup menus.
2. Press ▼ to go to the appropriate a menu.
3. If applicable, press LOOP to choose the loop that you want to edit.
4. Press ▶ to go to the parameter that you want to edit.
5. To edit a parameter:
   - Press ▼ or ▲ to choose a value.
   - Press ▶ to save the new value and go to the next parameter.
   - Press ↩ to cancel a change without saving.
6. Repeat from step 4 to edit another parameter in the current menu.
7. Press ↩ to return to the top-level menus.
8. Repeat from step 2 to go to another menu, or press ↩ to exit the setup menus.

For information about setting parameters through serial communications or LogicPro programs, see *Setting Parameters Through Serial Communications or a LogicPro Program on page 78*.

Setting Up Closed-Loop Control

Closed-loop control is used to control an output based on feedback from a sensor or other signal.

Feedback

The controller receives electrical signals, or feedback, from a sensor or other device. The input parameters determine how the controller interprets the signal. The controller interprets or scales the input signal in engineering units such as °C or °F.

Control Algorithm

When the controller is in automatic control mode and a set point is supplied, the controller determines the appropriate output signal.

The controller calculates the output signal based on the feedback and the control algorithm. Each loop may use either on/off control or any combination of proportional, integral and derivative (PID) control. See the Tuning and Control chapter for information about these control modes.

TRU-TUNE+™

When the controller is in the adaptive control mode, it determines the appropriate output signal and, over time, adjusts the control parameters to optimize responsiveness and stability. This function is available only for heat and cool outputs not using on/off control

Control Output Signal Forms

The output level calculated by the controller is represented by a percentage (0 to 100 percent) of power to be applied. That value is applied on a digital or analog output according to the user-selected output type. See *Heat / Cool Output Type on page 116* for more information about the output types available.

Heat and Cool Outputs

In some applications, two outputs may be controlled according to one input. For example, a loop with both heat and cooling water flow might be controlled according to feedback from one thermocouple.

In such systems, the control algorithm includes provisions to avoid switching too frequently between the heat and cool outputs. The on/off algorithm uses a hysteresis parameter. The PID algorithms use both a hysteresis parameter and

the PID parameters to determine when control switches between heating and cooling.

How to Set Up Closed-Loop Control

The following are the basic steps to set up closed-loop control for a typical control loop:

1. Use the *Input* menu to specify the type of input signal and, if necessary, how to scale that signal.
2. If using on/off or both heat and cool outputs, use the *Control* menu to specify the control hysteresis.
3. Use the *Output* menu to enable the heat and/or cool outputs and to specify the control output signal form.
4. Enter a set point. See *Changing the Set Point on page 54*.
5. Put the channel in Tune mode. See *Changing the Control Mode and Output Power on page 55*.

For more information about the setup menus and parameters, see *Chapter 5, Menu and Parameter Reference*.

Setting Up a Process or Pulse Input

If you use a process or pulse input signal, you must set up scaling parameters in the *Input* menu to scale the raw input signals to the engineering units of the process.

Input Scaling

To scale the input, you enter values that represent two points on a conversion line. Each point indicates an input signal level and the corresponding process value.

For a pulse input, the input signal range is 0 to 2000 Hz. For a process input, the input signal is expressed as percent of full range. For example, for a 0 to 20 mA process input, 0 mA is 0 percent, 10 mA is 50 percent, and so on.

The conversion line scales the input signal to the engineering units of the process. For example, in *Figure 3.6*, a 20 percent input signal corresponds to 8 pounds per square inch (PSI), and a 100 percent signal corresponds to 28 PSI.

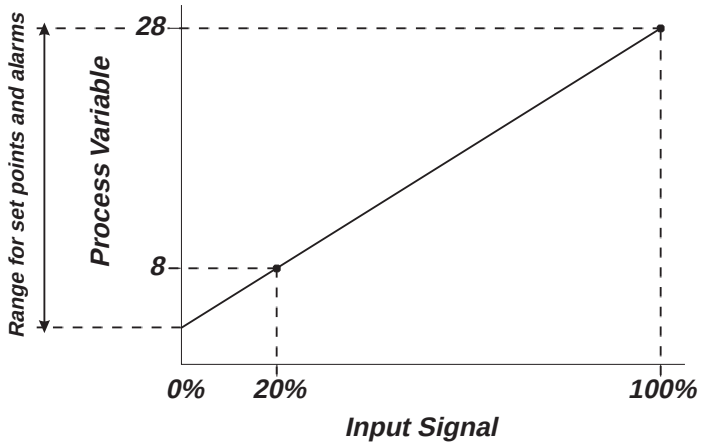


Figure 3.6 Input Scaling

The range for set points and alarms is bound by the process variables that correspond to the 0 percent and 100 percent input signals (or the 0 Hz and 2000 Hz signals for pulse inputs). Bear in mind that the range for set points and alarms is *not* bound by the low and high process variable ranges that you enter in the scaling parameters.

Input Scaling Example: 4 to 20 mA Sensor

Situation

Suppose the controller has a 0 to 20 mA process input that is connected to a pressure sensor. The pressure sensor has a range of 4 to 20 mA, representing 0.0 to 50.0 pounds per square inch (PSI).

Setup

Set the scaling parameters in the *Input* menu as follows:

- For the *Input type* parameter, choose *process*.
- For the *Disp format* parameter, choose *-999.9 to 3000.0*, because the sensor measures PSI in tenths.
- For the *Input signal low* and *Input signal high* parameters, use the minimum and maximum range of the sensor. In this case, the sensor range is 4 to 20 mA. The range must be expressed in percent of full scale. To determine the percentages, divide the minimum and maximum sensor range (4 mA and 20 mA) by the maximum signal that the controller can accept (20 mA):
  - *Input signal low* = 4 mA/20 mA = 0.2 = 20%

- *Input signal high* = 20 mA/20 mA = 1.0 = 100%

- For the *Input range low* and *Input range high* parameters, enter the process values that correspond to the low and high signals. In this case, a 20 percent (4 mA) signal represents 0.0 PSI. A 100 percent (20 mA) signal represents 50.0 PSI.

Table 3.4 Input Readings

Process Variable Displayed	Sensor Input	Reading in Percent of Full Scale
50.0 PSI	20 mA	100%
.0 PSI	4 mA	100% x (4 mA/20 mA) = 20%

Table 3.5 Scaling Values

Parameter	Value
Input range high	50.0 PSI
Input high signal	100.0%
Input range low	.0 PSI
Input low signal	20.0%

Input Scaling Example: 0 to 5V⎓ (dc) Sensor

Situation

A flow sensor connected to the controller measures the flow in a pipe. The sensor generates a 0 to 5V⎓ (dc) signal. Independent calibration measurements of the flow in the pipe indicate that the sensor generates 0.5V at 3 gallons per minute (GPM) and 4.75 V at 65 GPM. The calibration instrument is accurate ±1 GPM.

Setup

For the *Disp format* parameter in the *Input* menu, choose *-999 to 3000*, because the calibrating instrument is precise to ±1 GPM.

The tables below show the minimum and maximum input signals and their corresponding process variables, and the resulting values for the scaling parameters.

Table 3.6 Input Readings and Calculations

Process Variable Displayed	Sensor Input	Reading in Percent of Full Scale
65 GPM	4.75 V	(4.75 V / 5.00 V) x 100% = 95%
3 GPM	0.5 V	(0.5 V / 5.00 V) x 100% = 10%

Table 3.7 Scaling Values

Parameter	Value
Input range high	65 GPM
Input high signal	95.0%
Input range low	3 GPM
Input low signal	10.0%

Input Scaling Example: Pulse Encoder

Situation

A pulse encoder measures the movement of a conveyor. The encoder generates 900 pulses for every inch the conveyor moves. You want to measure conveyor speed in feet per minute (FPM).

Setup

The encoder input is connected to the pulse input (loop 5 on a CPC404, loop 9 on a CPC408). On that loop, set the *Input type* parameter to *pulse*.

Set the *Input pulse sample* parameter to *1 sec*, because a one-second sample time gives adequate resolution of the conveyor speed. The resolution is 0.006 feet per minute:

$$\frac{1 \text{ pulse}}{1 \text{ second}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} \times \frac{1 \text{ inch}}{900 \text{ pulses}} \times \frac{1 \text{ foot}}{12 \text{ inches}} = 0.006 \text{ FPM}$$

Since the resolution is in thousandths, the *Disp format* parameter is set to *-9.999to 30.000*.

To determine the settings for the *Input low range* and *Input high range* parameters, calculate the process variable values when the input signal is 0 Hz and 2000 Hz. (You could calculate the values at other frequencies.)

- At 0 Hz, the process variable is 0.000 FPM.
- At 2000 Hz, the process variable is 11.111 FPM:

$$\frac{2000 \text{ pulses}}{1 \text{ second}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} \times \frac{1 \text{ inch}}{900 \text{ pulses}} \times \frac{1 \text{ foot}}{12 \text{ inches}} = 11.111 \text{ FPM}$$

Table 3.8 Scaling Values

Parameter	Value
Input range high	11.111 FPM
Input high signal	2000 Hz
Input range low	0.000 FPM
Input low signal	0 Hz

Autotuning

Autotuning with TRU-TUNE+™ adaptive control is a process by which the CPC400 controller calculates the PID parameters for optimum control. Both heating and cooling PID parameters are set.

The preferred and quickest method for tuning a loop is to use the tune mode to establish initial control settings and continue with the adaptive mode to fine tune the settings. Setting a loop's control mode to *tune* starts this two-step tuning function. First a predictive tune determines initial, rough settings for the PID parameters. Second the loop automatically switches to the adaptive mode which fine tunes the PID parameters. This function can be used for heat-only, heat and cool, and cool-only PID control systems.

Once the process variable has been at set point for a suitable period of time (about 30 minutes for a fast process to roughly 2 hours for a slower process) and if no further tuning of the PID parameters is desired or needed, the control mode may be switched to *auto*. However, only operating the controller in the adaptive mode allows it to automatically adjust to load changes and compensate for differing control characteristics at various set points for processes that are not entirely linear.

Once the PID parameters have been set by the TRU-TUNE+™ adaptive algorithm, the process, if shut down for any reason, can be restarted in the adaptive control mode.

Before Tuning

Before autotuning, the controller hardware must be installed correctly, and these basic configuration parameters must be set:

- *Input type* (and scaling, if required)
- *Output type* (and scaling, if required)

- *Heat power limit* (if the heat output is used and 100% power is not safe)
- *Cool power limit* (if the cool output is used and 100% power is not safe)

How to Autotune a Loop

1. Go to the loop display (see *Loop Display on page 50*) and press LOOP to choose the loop to tune.
2. Enter the desired set point or one that is in the middle of the expected range of set points that you want to tune for. (See page 54.)
3. Set the control mode to *tune*. (See page 55.)

After the control mode on the loop display has switched to *adpt* and stopped flashing, the PID parameters should be close enough to provide good control. As long as the loop is in the adaptive control mode, TRU-TUNE+™ continuously tunes to provide the best possible PID control for the process.

WARNING! ***During autotuning, the controller sets the output to 100 percent and attempts to drive the process variable toward set point. Enter a set point and heat and cool power limits that are within the safe operating limits of your system.***

Setting Up Alarms

The CPC400 has three main types of alarms:

- Failed sensor alarms
- Process alarms
- System alarms

Failed Sensor Alarms

Failed sensor alarms alert you if one of the following conditions occurs:

- Thermocouple open
- Thermocouple shorted (must be enabled)
- Thermocouple reversed (enabled by default)
- RTD open positive input or open negative input
- RTD short between the positive and negative inputs

What Happens if a Failed Sensor Alarm Occurs?

If a failed sensor alarm occurs:

- The controller switches to manual mode at the output power indicated by the *Sensor fail heat output* and *Sensor fail cool output* parameters in the *Output* menu. (The output power may be different for a thermocouple open alarm; see Thermocouple Open Alarm below.)
- The controller displays an alarm code and alarm message on the display. See *Alarm Displays on page 51*.
- The global alarm output is activated.

Thermocouple Open Alarm

The thermocouple open alarm occurs if the controller detects a break in a thermocouple or its leads.

If a thermocouple open alarm occurs, the controller switches to manual mode. The output level is determined as follows:

- If the *Open T/C ht/cl out average* parameter in the *Output* menu is set to *on*, then the controller sets the output power to an average of the recent output.
- If the *Open T/C ht/cl out average* parameter is set to *off*, then the controller sets the output to the level indicated by the *Sensor fail heat/cool output* parameter in the *Output* menu.

Thermocouple Reversed Alarm

The thermocouple reversed alarm occurs if the temperature goes in the opposite direction and to the opposite side of ambient temperature than expected—for example, a loop is heating and the measured temperature drops below the ambient temperature.

The thermocouple reversed alarm is enabled by default. If false alarms occur in your application, you can disable the alarm by setting the *Reversed T/C detect* parameter to *off*. See *Reversed Thermocouple Detection on page 106*.

Thermocouple Short Alarm

The thermocouple short alarm occurs if the process power is on and the temperature does not rise or fall as expected. To enable the thermocouple short alarm, you must do the following:

- Choose a digital input for the *TC short alarm* parameter in the *Global setup* menu.
- Connect the digital input to a device that connects the input to controller common when the process power is on.

RTD Open or RTD Shorted Alarm

The RTD open alarm occurs if the controller detects that the positive or negative RTD lead is broken or disconnected.

The RTD shorted alarm occurs if the controller detects that the positive and negative RTD leads are shorted.

You do not have to set any parameters for the RTD alarms.

Restore Automatic Control After a Sensor Failure

This feature returns a loop to automatic control after a failed sensor is repaired. To enable this feature:

- Choose a digital input for the *RestoreAuto* parameter in the *Control* menu.
- Connect the digital input to the dc common terminal on the controller.

Process Alarms

The CPC400 has four process alarms, each of which you can configure separately for each loop:

- Alarm low
- Alarm high
- Low deviation alarm
- High deviation alarm

What Happens if a Process Alarm Occurs?

If a process alarm occurs, the controller does the following:

- Shows an alarm code on the display. See *Alarm Displays on page 51*.
- Activates the global alarm output. See *Global Alarm on page 67*.
- Activates the digital output that is assigned to the process alarm (if applicable). The digital output remains active until the process variable returns within the corresponding limit and hysteresis. The alarm output deactivates when the process returns to normal.

Process Alarm Outputs

Any digital output that is not used as a control output can be assigned to one or more process alarms.

The controller activates the output if any alarm assigned to the output is active. Process alarm outputs are non-latching—that is, the output is deactivated when the process returns to normal, whether or not the alarm has been acknowledged.

Specify the active state of process alarm outputs at the *D/O alarm polarity* setting in the *Global setup* menu.

Alarm Function: Standard Alarm or Boost Output

You can configure each process alarm as either a standard alarm or a boost alarm:

- A standard alarm provides traditional alarm functionality: The operator must acknowledge the alarm message on the controller display, a latching global alarm is activated, and the alarm can activate a user-specified non-latching alarm output.
- A boost alarm provides on/off control output using the alarm set points. For example, you could configure a high deviation alarm to turn on a fan. The alarm activates a user-specified non-latching output. Alarm messages do not have to be acknowledged, and the global alarm is not activated.

Alarm High and Alarm Low

An alarm high occurs if the process variable rises above a user-specified value. An alarm low occurs if the process variable drops below a separate user-specified value. See *Figure 3.7*

Enter the alarm high and low set points at the *Alarm high SP* and *Alarm low SP* parameters in the *Alarms* menu.

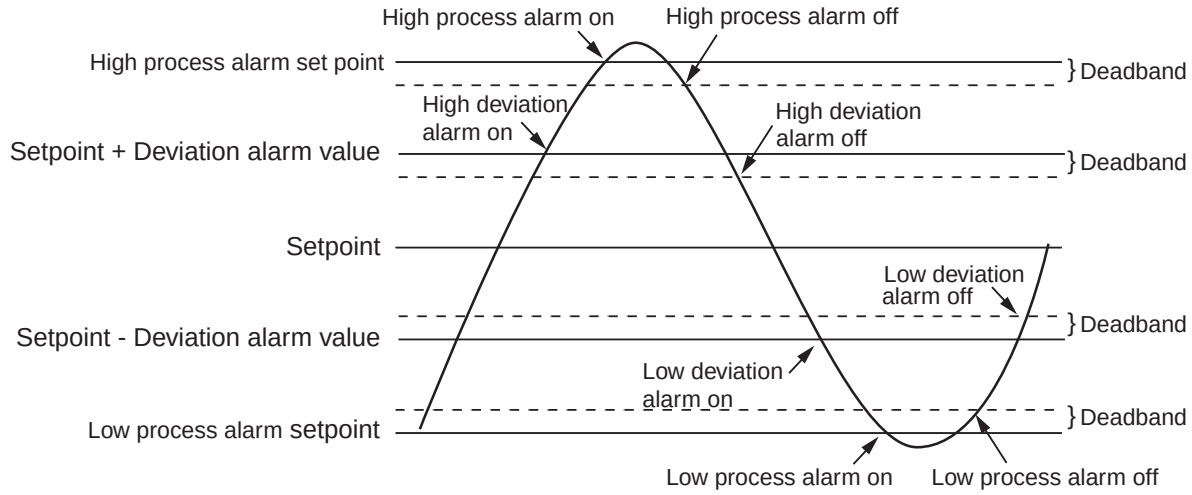


Figure 3.7 Activation and Deactivation of Process Alarms

Deviation Alarms

A deviation alarm occurs if the process deviates from set point by more than a user-specified amount; see *Figure 3.7*. You can set separate high and low deviation values at the *HiDeviation value* and *LoDeviation value* parameters in the *Alarms* menu.

Upon power up or when the set point changes, the behavior of the deviation alarms depends upon the alarm function:

- If the alarm function parameter is set to *standard*, then deviation alarms do not activate until the after the process variable has first come within the deviation alarm band. This prevents nuisance alarms.
- If the alarm function parameter is set to *boost*, then the deviation output switches on whenever the set point and process variable differ by more than the deviation setting, regardless of whether the process variable has been within the deviation band. This allows you to use boost control upon power up and set point changes.

Global Alarm

The CPC400 comes equipped with a global alarm output. The global output is activated if one or more of the following conditions occurs:

- A system alarm occurs, or
- A failed sensor alarm occurs and is unacknowledged, or
- A process alarm occurs and is unacknowledged. The global alarm occurs only if the alarm function is set to *standard* in the *Alarms* menu. (The global alarm does *not* occur if the alarm function is set to *boost*.)

The global alarm output stays active until all alarms have been acknowledged.

When the global alarm output is active, it conducts current to the controller's dc common. When the global alarm output is not active, it does not conduct current.

NOTE! ***You cannot configure any parameters for the global alarm. The active state of the global alarm output is NOT affected by the* D/O alarm polarity *parameter in the* Global setup *menu.***

Setting Up Process Variable Retransmit

The process variable retransmit feature retransmits the process variable of one loop (primary) via the control output of another loop (secondary). This signal is linear and proportional to the engineering units of the primary loop input.

Typical uses include data logging to analog recording systems, and long distance transmission of the primary signal to avoid signal degradation. The retransmitted signal can also be used as an input to other types of control systems such as a PLC.

Any available heat or cool output may be used as a retransmit output. Any process variable may be retransmitted, including the input from the same loop.

To get a 4 to 20 mA or 0 to 5V⎓ (dc) signal, the controller output signal must be connected to a Serial DAC.

How to Set Up Process Variable Retransmit

1. Configure all of the setup parameters for the primary loop (the loop whose input signal will be retransmitted).
2. Choose an unused control output to retransmit the input signal. This output may be on the primary loop or on a different loop.
3. On the secondary loop (the loop whose output will retransmit the signal):
   - Set up the parameters in the *PV retrans* menu. See *Process Variable Retransmit Menu on page 125*.
   - Enable the loop's output and configure it to meet the requirements of the application.
4. If the signal is being retransmitted to another controller, configure the input of that controller to accept the linear output signal produced by the retransmit output.

Process Variable Retransmit Example: Data Logging

The CPC400 controls the temperature of a furnace. The thermocouple in one of the zones is connected to the controller and is used for closed-loop PID control. An analog recorder data logging system is also in place, and a recording of the process temperature is required. The recorder requires a linear 4 to 20 mA input signal, which represents a process variable range of 0 to 1000°F.

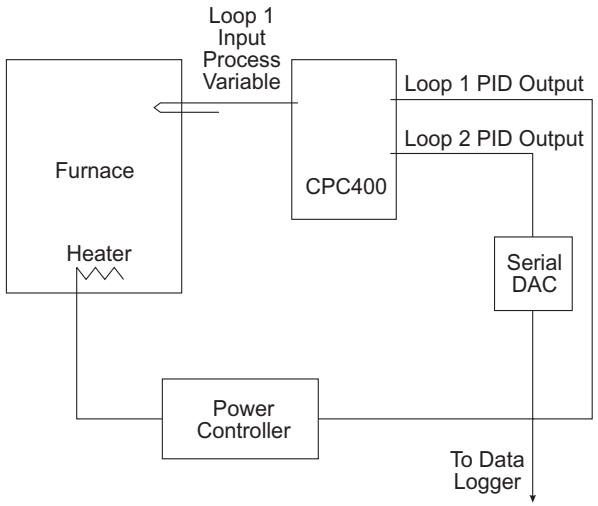


Figure 3.8 Application Using Process Variable Retransmit

Table 3.9 shows the parameter setup for this example.

Table 3.9 Parameters Settings for Process Variable Retransmit Example

Menu	Parameter	Value	Comment
PV retrans	Ht output retrans	PV 1	Choose to retransmit the loop 1 process variable.
PV retrans	Ht retrans LowPV	0°F	This is the input value represented by a 0 percent output signal. The recorder input is a linear 4 to 20 mA signal representing a range of 0 to 1000°F, so we will use a 0 percent output signal to represent 0°F.
PV retrans	Ht retrans HighPV	1000°F	This is the input value represented by a 100 percent output signal. The recorder input is a linear 4 to 20 mA signal representing a range of 0 to 1000°F, so we will use a 100 percent output signal to represent 1000°F.
PV retrans	Cl output retrans	none	Not using the cool output of loop 2 to retransmit a process variable.

To complete this configuration, the output for loop 2 must be configured to provide the 4 to 20 mA analog signal (via the Serial DAC) that is required by the data logger.

When setup is completed, the controller will produce an output on loop 2 which is linear and proportional to the loop 1 process variable.

Setting Up Cascade Control

Cascade control is used to control thermal systems with long lag times, which cannot be as accurately controlled with a single control loop. The output of the first (primary) loop is used to adjust the set point of the second (secondary) loop. The secondary loop normally executes the actual control.

Some applications, such as aluminum casting, use two-zone cascade control where the primary output is used for the primary heat control and the cascaded output is used for boost heat. You can use the primary heat output for both control *and* for determining the set point of the secondary loop.

How the Secondary Set Point is Determined

The set point of the secondary loop is determined according to the heat and cool output values from the primary loop and user-specified cascade parameters:

- If the primary loop has both heat and cool outputs, then the set point of the secondary loop is equal to the *Cascade low SP* parameter when the cool output is at 100 percent, and is equal to the *Cascade high SP* when the heat output is at 100 percent. See *Figure 3.9*.
- If the primary loop has only a heat output, then the set point of the secondary loop is equal to the *Cascade low SP* parameter when the heat output is at 0 percent, and is equal to the *Cascade high SP* parameter when the heat output is at 100 percent. See *Figure 3.10*.
- If the primary loop has only a cool output, then the set point of the secondary loop is equal to the *Cascade low SP* parameter when the cool output is at 100 percent, and is equal to the *Cascade high SP* parameter when the cool output is at 0 percent.

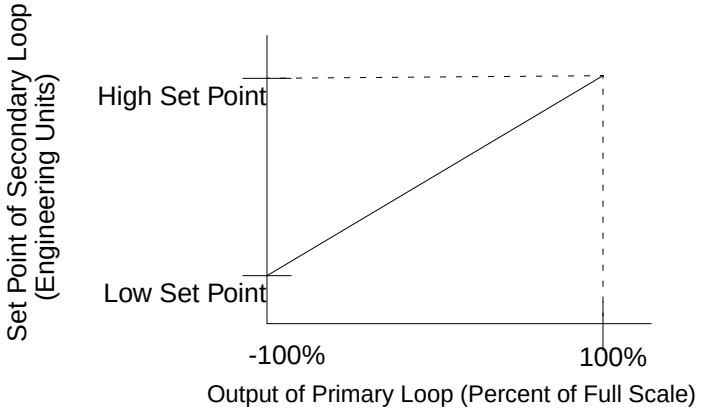


Figure 3.9 Secondary Set Point When Primary Loop Has Heat and Cool Outputs

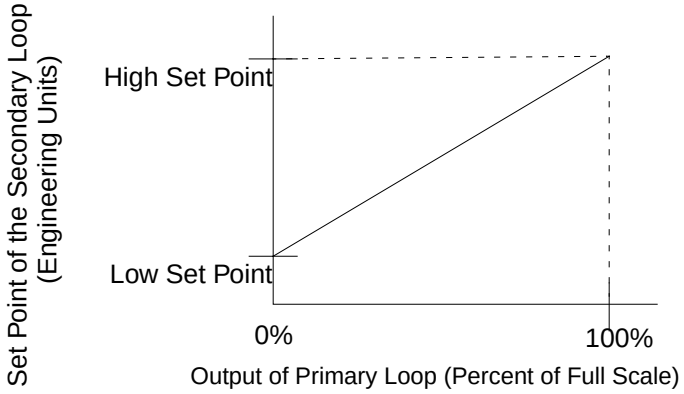


Figure 3.10 Secondary Set Point When Primary Loop Has Heat Output Only

Proportional-Only Control on the Primary Loop

The PID parameters of the primary loop must be tuned to produce the desired effect on the set point of the secondary loop. The primary loop typically uses proportional-only control. Disabling the integral and derivative components of PID makes the secondary set point a predictable function of the primary loop's process variable.

The proportional band is selected so that the set point of the secondary loop has the desired relationship to the process variable of the primary loop. For an example, see *Cascade Control Example: Water Tank on page 71*.

How To Set Up Cascade Control

1. For the primary cascade loop:
   - Configure proportional-only control. For an example, see *Cascade Control Example: Water Tank on page 71*.
   - Enter the desired set point. See *Changing the Set Point on page 54*.
2. For the secondary cascade loop:
   - Set up PID control as you would for a standard closed-loop application.
   - Set up the parameters in the *Cascade* menu. See *Cascade Menu on page 127*.

NOTE! ***Cascade control cannot be used on the same control loop as ratio control.***

Cascade Control Example: Water Tank

A tank of water has an inner and outer thermocouple. The outer thermocouple is located in the center of the water. The inner thermocouple is located near the heating element. The desired temperature of the water is 150°F, which is measured at the outer thermocouple.

Using cascade control, the outer thermocouple is used on the primary loop (in this example, loop 1), and the inner thermocouple is used on the secondary loop (loop 2). The heater is controlled by loop 2.

As the temperature of the inner thermocouple drops from 150 to 140°F, the set point of the secondary loop should rise from 150 to 190°F.

Table 3.10 and *Table 3.11* show the setup for this application.

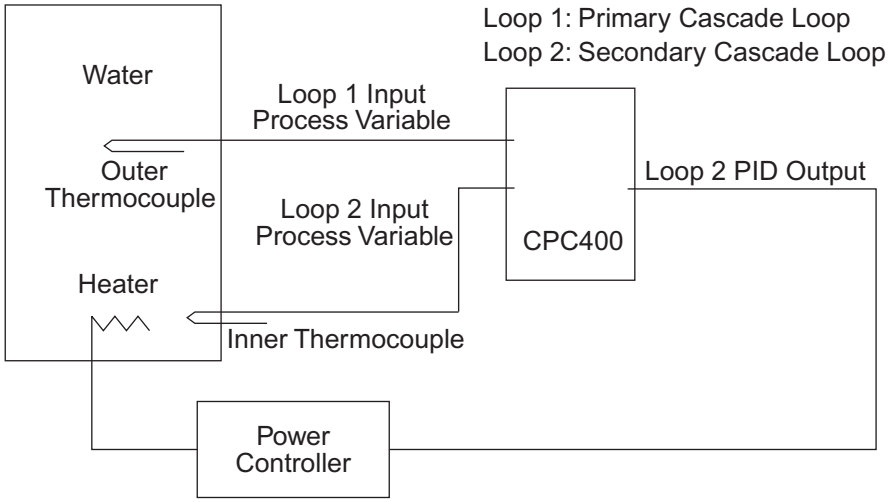


Figure 3.11 Example Application Using Cascade Control

Table 3.10 Parameter Settings for the Primary Loop in the Cascade Example

Menu	Parameter	Value	Comment
(none)	Set point	150°F	Desired temperature at the inner thermocouple.
Control	Ht prop band	10	As the input drops 10°F, the output increases to 100 percent.
Control	Ht integral	0	Only proportional control is used.
Control	Ht derivative	0	Only proportional control is used.

Table 3.11 Parameter Settings for the Secondary Loop in the Cascade Example

Menu	Parameter	Value	Comment
Cascade	Cascade prim loop	1	Loop 1 is the primary loop.
Cascade	Cascade low SP	150°F	When the primary loop's output is 0 percent, the secondary loop's set point is 150°F.
Cascade	Cascade high SP	190°F	When the primary loop output is 100 percent, the secondary channel set point is 190°F.

As the temperature in the middle of the tank (loop 1) drops, the output goes up proportionally and the set point of loop 2 goes up proportionally. Thus heat is added to the system at the element even though the temperature near the element may have been at the desired temperature.

With proportional control, when loop 1 is at set point, its output is 0 percent, and the set point of loop 2 is equal to the desired temperature 150°F. If the temperature of the loop 1 drops below 149°F, the deviation results in a proportional output of 10 percent. This results in an increase to the set point for loop 2 equal to 10 percent of the set point range. In this case the range is 40°F (190 - 150°F = 40°F), and 10 percent of 40°F is 4°F.

So when the temperature at loop 1 drops 1°F, the set point of loop 2 increases by 4°F until the output of loop 1 is 100 percent and the set point of loop 2 is 190°F. At this point, further decreases of the loop 1 process variable have no additional affect on loop 2. *Figure 3.12* illustrates this relationship.

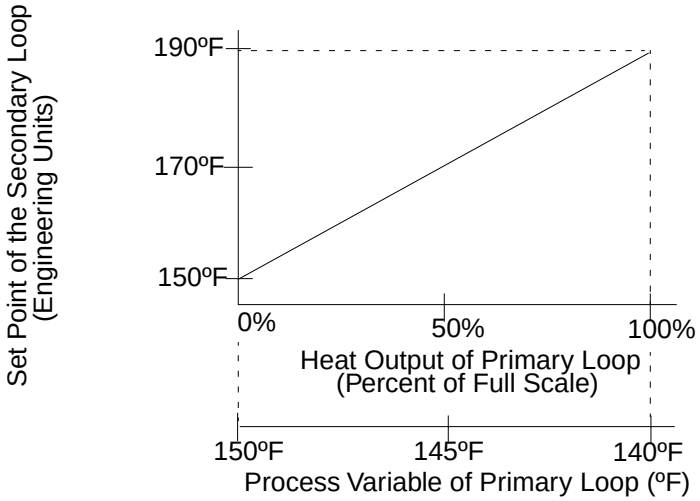


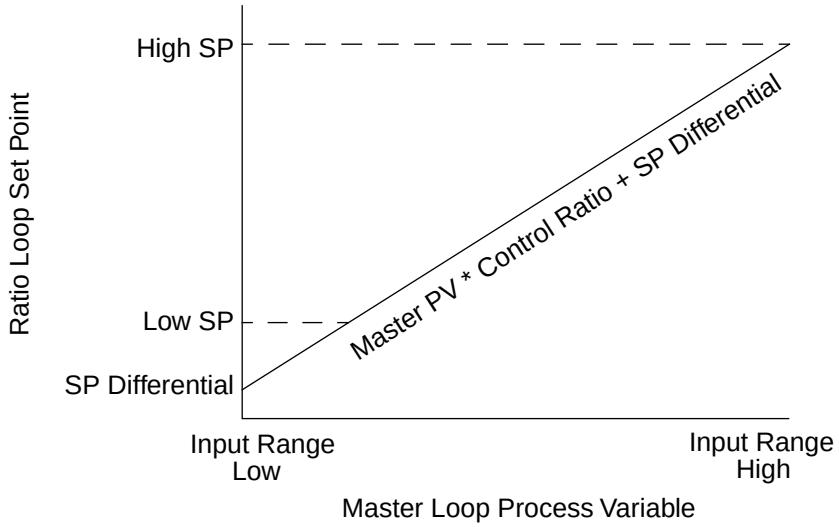
Figure 3.12 Relationship of Secondary Loop Set Point to Primary Loop Process Variable in Cascade Example

Setting Up Ratio Control

Ratio control allows the process variable of one loop (master loop), multiplied by a ratio, to be the set point of another loop (ratio loop). You can assign any process variable to determine the set point of a ratio loop.

By adjusting the ratio control parameters, you can adjust the influence that the master loop process variable has on the set point of the ratio loop

.



SP = Set Point
PV = Process Variable

Figure 3.13 Relationship Between the Process Variable on the Master Loop and the Set Point of the Ratio Loop

NOTE! ***Ratio control cannot be used on the same control loop as cascade control.***

How to Set Up Ratio Control

1. Adjust and tune the master loop for optimal performance before implementing the ratio setup.
2. For the ratio loop, set the parameters in the *Ratio* menu.
3. Configure both the master loop and the ratio loop for inputs, outputs, and alarms.

Ratio Control Example: Diluting KOH

A chemical process requires a formula of two parts water (H_2O) to one part potassium hydroxide (KOH) to produce diluted potassium hydroxide. The desired flow of H_2O is 10 gallons per second (gps), so the KOH should flow at 5 gps.

Separate pipes for each chemical feed a common pipe. The flow rate of each feeder pipe is measured by a CPC400, with H_2O flow measured on loop 1 and KOH flow measured on loop 2. The outputs of loops 1 and 2 adjust motorized valves.

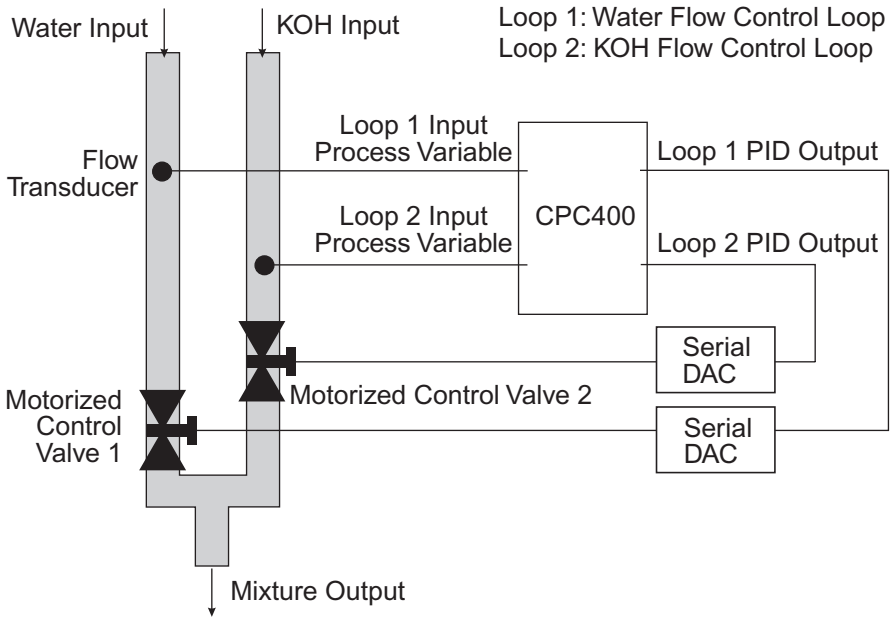


Figure 3.14 Application Using Ratio Control

Table 3.12 Ratio Control Settings for the Ratio Loop (Loop 2) in the Example

Menu	Parameter	Value	Comment
Ratio	Ratio master loop	01	Loop 1 is the master loop.
Ratio	Ratio low SP	0.0	The minimum ratio loop set point is 0.0 gallons per second (gps).
Ratio	Ratio high SP	7.0	The maximum ratio loop set point is 7.0 gps.
Ratio	Control ratio	0.5	The H_20 flow rate (10 gps) is multiplied by 0.5 to obtain the KOH flow rate (5 gps).
Ratio	Ratio SP diff	0	For this example, there is no set point differential.

Setting Up Differential Control

Differential control is a simple application of ratio control, used to control one process (ratio loop) at a differential, or offset, to another process (master loop).

How to Set Up Differential Control

Set up differential control as you would set up ratio control. Set the *Control ratio* parameter to 1.0, and enter the desired set point differential (offset) at the *Ratio SP diff* parameter.

Differential Control Example: Thermoforming

A thermal forming application requires that the outer heaters operate at temperature 50ºF hotter than the center heaters. The center heaters use infrared (IR) sensors for temperature feedback. The outer heaters use thermocouples for feedback.

We can use differential control to control the outer heaters at a 50ºF differential to the central heaters. For example, if the set point for the center heaters is 325ºF, the set point of the outer heaters will be 375ºF.

In this application, the center heaters will be controlled by the master loop (on loop 1), and the outer heaters will be controlled by the ratio loop (on loop 2).

To set up this application, first set up the master loop (loop 1) for PID control with a set point of 325ºF. Then, for the ratio loop (loop 2), set the parameters in the *Ratio* menu as shown in *Table 3.13*.

Table 3.13 Parameter Settings for the Ratio Loop (Loop 2) for the Example

Menu	Parameter	Value	Comment
Ratio	Ratio master loop	01	Loop 1 is the master loop.
Ratio	Ratio low SP	300.0°F	The lowest allowable set point for the ratio loop. For this example, we'll use 300.0.
Ratio	Ratio high SP	400.0°F	The highest allowable set point for the ratio loop. For this example, we'll use 400.0.
Ratio	Control ratio	1.0	For differential control, always set this parameter to 1.0.
Ratio	Ratio SP diff	50°F	The set point differential, or offset.

To complete the differential control setup, loop 1 and loop 2 must be configured for inputs, outputs and alarms.

Setting Up Remote Analog Set Point

Remote analog set point allows external equipment, such as a PLC or other control system, to change the set point of a loop.

Typically, a voltage or current source is connected to an analog input on the controller, and this input is configured as the master loop for ratio control.

Proper scaling resistors must be installed on the input to allow it to accept the analog input signal.

How to Set Up a Remote Analog Set Point

1. For the master loop (the loop that accepts the input signal from the external device), set the parameters in the *Input* menu.
2. For the ratio loop (the one whose set point is controlled by the external device), set the parameters in the *Ratio* menu. Specify the loop that accepts the input signal as the master loop.

Remote Analog Set Point Example: Changing a Set Point with a PLC

A PLC provides a 0 to 5V⎓ (dc) signal representing 0 to 300°F as a remote set point input to the CPC400. The input signal is received on loop 1, and control is performed on loop 2. The CPC400 is equipped with the proper scaling resistors to allow it to accept a 0 to 5V⎓ (dc) input.

Table 3.14 and *Table 3.15* show the parameter settings for this application.

Table 3.14 Parameters Settings for the Master Loop (Loop 1) in the Example

Menu	Parameter	Value	Comment
Input	Input type	process	A 0 to 5V⎓ (dc) input signal is a process input.
Input	Input range high	300°F	The 5V⎓ (dc) input signal represents 300°F.
Input	Input high signal	100.0%	The controller is equipped with a 0 to 5V⎓ (dc) input, and the input signal is 0 to 5V⎓ (dc), so the signal covers the full scale of 0 to 100 percent.
Input	Input range low	0°F	The 0V⎓ (dc) input signal represents 0°F.
Input	Input low signal	0.0%	The controller is equipped with a 0 to 5V⎓ (dc) input, and the input signal is 0 to 5V⎓ (dc), so the signal covers the full scale of 0 to 100 percent.

Table 3.15 Parameter Settings for the Ratio Loop (Loop 2) in the Example

Menu	Parameter	Value	Comment
Ratio	Ratio master loop	01	Loop 1 is the master loop (receives the input signal from the external device).
Ratio	Ratio low SP	0°F	For this example, we will assume that the process can be set safely over the entire range of 0 to 300°F. If desired, we could set a more restrictive range for the ratio loop.
Ratio	Ratio high SP	300°F	
Ratio	Control ratio	1.0	For this example, we want to retain the original input value, so we will multiply it times 1.0.
Ratio	Ratio SP diff	0	For this example, we want to retain the original value, so we will add 0.

To complete the setup, loop 2 must be configured for inputs, outputs, and alarms. In addition, loop 1 may be configured for outputs and alarms.

Setting Parameters Through Serial Communications or a LogicPro Program

All values stored in the CPC400 are bits or integers. Some integers represent settings that appear as text in the controller interface or HMI program. Some integers represent numeric settings.

When you read a parameter value using serial communications or a LogicPro program, you read an integer or a bit. To interpret this value or set a new value, you must know the setting to which the integer value corresponds.

Non-Numeric Settings

When the controller interface displays the setting as a word, a phrase and in some cases a number, see the parameter information in the *Menu and Parameter Reference* chapter. The integer value appears in parentheses following each option. Use that integer value when you set or interpret the value of the parameter using serial communications or a LogicPro program.

Bit-Wise Values

Some settings, such as enabling alarms, are stored as bits within words. With LogicPro, you can use the CALC function block's "AND" operator on the value and a mask word to read or change the particular bit in which you are interested.

For example, the bit that indicates whether or not the high deviation alarm has been acknowledged is the forth bit in the alarm acknowledge word for each channel. To determine if the high deviation alarm has been acknowledged for a channel, extract the fourth bit from that channel's alarm acknowledge parameter by ANDing it with a word that is all zeros except the fourth bit (0000 0000 0000 1000, or 8 in decimal). If the result of the calculation is 0 the fourth bit was not set. If the result of the calculation is 8 the bit was set.

	0000 0000 0011 1100	(60 decimal) channel's alarm acknowledge parameter value
	AND	
	0000 0000 0000 1000	(8 decimal) mask for the fourth bit
	---	
is	**0000 0000 0000 1000**	(8 decimal) The resulting value indicates that the bit was set.

To set a bit use the CALC function block's "OR" operator and the appropriate mask word to change the value of the word. For example, to enable the low deviation alarm for a channel, you must set the third bit of that channel's alarm enable parameter:

	0000 0001 1111 1000	(504 decimal) channel's alarm enable parameter value
	OR	
	0000 0000 0000 0100	(4 decimal) mask for the third bit
	---	
is	**0000 0000 1111 1100**	(508 decimal) The new value is unchanged except for the third bit.

To clear a bit use the CALC function block's "AND" operator and an inverse mask. For example, to set the alarm function for a channel's low deviation alarm to "boost," you must clear the third bit of that channel's alarm function parameter:

	0000 0000 0000 1100	(12 decimal) channel's alarm function parameter value
	AND	
	1111 1111 1111 1011	(65,531 decimal) the inverse mask for the third bit
	---	
is	**0000 0000 0000 1000**	(8 decimal) The new value is unchanged except for the third bit.

NOTE! ***Throughout this manual, we refer to the least significant bit as the first bit.***

Decimal Placement for Numeric Values

Numeric values that are in the loop's engineering units are stored as integers. The number of decimal places that are assumed when a parameter value is stored in the controller depends upon the *Input type* and *Disp format* parameter values for the loop. See *Table 3.16*.

Table 3.16 Number of Decimal Places for Numeric Values via Modbus or Logic

Input Type	Display Format	Decimal Places
Any thermocouple or RTD	-999 to 3000	1
Process or pulse or soft integer used as an Analog Input	-999 to 3000	1
	-9999 to 30000	0
	-999.9 to 3000.0	1
	-99.99 to 300.00	2
	-9.999 to 30.000	3
	-0.9999 to 3.0000	4

To determine the integer value to set in the controller, move the decimal to the right the number of places specified.

For example:

- If a loop has a process input with a display format of -99.99 to 300.00, values are stored with two decimal places. If you read a value in the set point register of 2500, you should interpret that value as 25.00.
- If a loop has a thermocouple input and you want to set the *Alarm High SP* parameter to 355 through Modbus or logic, you should set a value of 3550.

Decimal Placement for Percentage Values

Percentage values are stored internally in tenths of a percent, such that 1000 corresponds to 100.0 percent. Divide values by ten when reading, and multiply values by ten before writing.

4

Tuning and Control

This chapter describes the different methods of control available with the CPC400. This chapter covers control algorithms, control methods, PID control, starting PID values and tuning instructions to help appropriately set control parameters in the CPC400 system.

For more information about PID control, consult the *Watlow Anafaze Practical Guide to PID*.

Control Algorithms

This section explains the algorithms available for controlling a loop.

The control algorithm dictates how the controller responds to an input signal. Do not confuse control algorithms with control output signals (for example, analog or pulsed dc voltage). There are several control algorithms available:

- On/off
- Proportional (P)
- Proportional and integral (PI)
- Proportional with derivative (PD)
- Proportional with integral and derivative (PID)

P, PI or PID control is necessary when process variable cycling is unacceptable or if the load or set point varies.

NOTE! ***For any of these control algorithms to function, the loop must be in automatic mode.***

On/Off Control

On/off control is the simplest way to control a process. The controller turns an output on or off when the process variable reaches limits around the desired set point. This limit is adjustable.

For example, if the set point is 1000°F and the control hysteresis is 20°F, the heat output switches on when the process variable drops below 980°F and off when the process rises above 1000°F. A process using on/off control cycles around the set point. *Figure 4.1* illustrates this example.

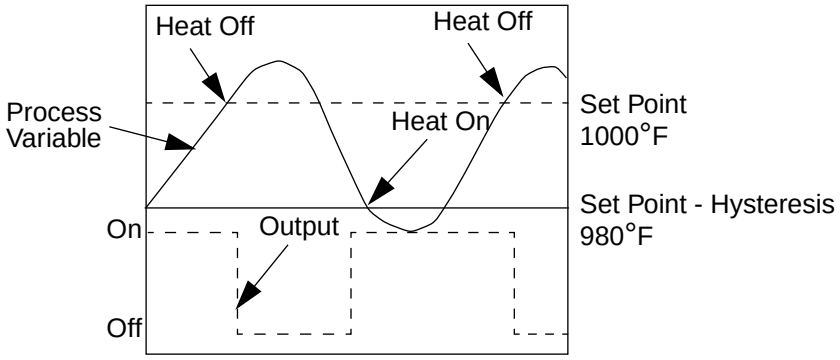


Figure 4.1 On/Off Control

Proportional Control (P)

Proportional control eliminates cycling by increasing or decreasing the output proportionally with the process variable's deviation from the set point.

The magnitude of proportional response is defined by the proportional band. Outside this band, the output is either 100 percent or 0 percent. Within the proportional band the output power is proportional to the process variable's deviation from the set point.

For example, if the set point is 1000°F and the proportional band is 20°F, the output power is as follows:

- 0 percent when the process variable is 1000°F or above
- 50 percent when the process variable is 990°F
- 75 percent when the process variable is 985°F
- 100 percent when the process variable is 980°F or below

However, a process that uses only proportional control settles at a point above or below the set point; it never reaches the set point. This behavior is known as *offset* or *droop*. When using proportional control, configure the manual reset parameter for the power level required to maintain set point.

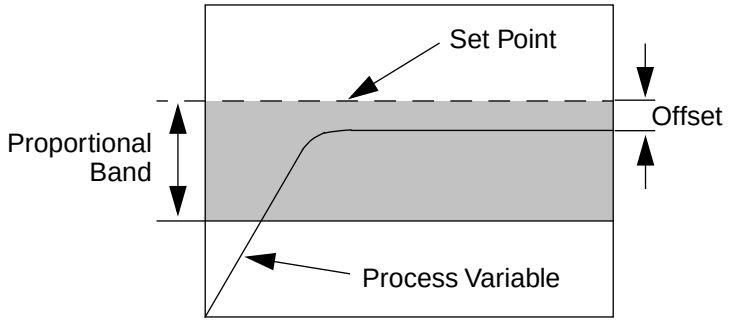


Figure 4.2 Proportional Control

Proportional and Integral Control (PI)

With proportional and integral control, the integral term corrects for offset by repeating the proportional band's error correction until there is no error. For example, if a process tends to settle about 5°F below the set point, appropriate integral control brings it to the desired setting by gradually increasing the output until there is no deviation.

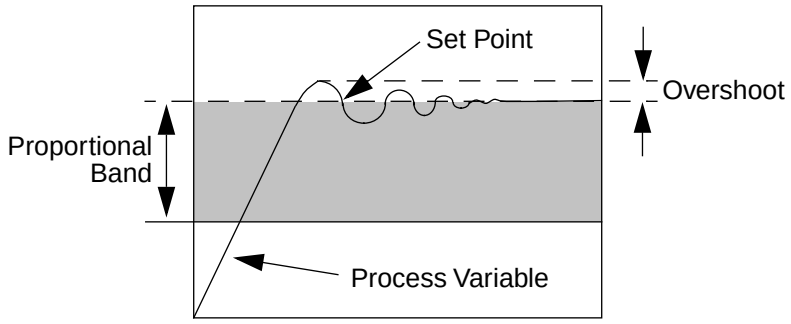


Figure 4.3 Proportional and Integral Control

Proportional and integral action working together can bring a process to set point and stabilize it. However, with some processes the user may be faced with choosing between parameters that make the process very slow to reach set point and parameters that make the controller respond quickly, but introduce some transient oscillations when the set point or load changes. The extent to which these oscillations of the process variable exceed the set point is called *overshoot*.

Proportional, Integral and Derivative Control (PID)

Derivative control corrects for overshoot by anticipating the behavior of the process variable and adjusting the output appropriately. For example, if the process variable is rapidly approaching the set point from below, derivative control reduces the output, anticipating that the process variable will reach set point. Use derivative control to reduce the overshoot and oscillation of the process variable that is common to PI control. *Figure 4.4* shows a process under full PID control.

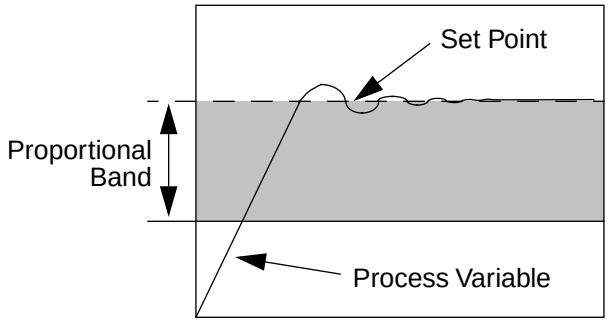


Figure 4.4 Proportional, Integral and Derivative Control

Heat and Cool Outputs

Each loop may have one or two outputs. Often a heater is controlled according to the feedback from a thermocouple, in which case only one output is needed.

In other applications, two outputs may be used for control according to one input. For example, a system with a heater and a proportional valve that controls cooling water flow can be controlled according to feedback from one thermocouple.

In such systems, the control algorithm avoids switching too frequently between heat and cool outputs. The on/off algorithm uses the control hysteresis parameter to prevent such oscillations (see Hysteresis on page 113). When PID control is used for one or both loop outputs, both the hysteresis parameter and PID parameters determine when control switches between heating and cooling.

Manually Tuning PID Loops

We recommend using the CPC400's advanced autotuning and TRU-TUNE+™ adaptive control capabilities to set up and maintain the PID control parameter settings. See *Autotuning on page 62*. It is, of course, possible to tune the controller manually. The information in this section is intended as a guide to that end.

When tuning a loop, choose PID parameters that will best control the process. This section gives PID values for a variety of heating and cooling applications.

NOTE! ***Tuning is a slow process. After adjusting a loop, allow about 20 minutes for the change to take effect.***

Proportional Band Settings

Table 4.1 shows proportional band settings for various temperatures in degrees Fahrenheit or Celsius.

Table 4.1 Proportional Band Settings

Temperature Set Point	PB	Temperature Set Point	PB	Temperature Set Point	PB
-100 to 99	20	1100 to 1199	75	2200 to 2299	135
100 to 199	20	1200 to 1299	80	2300 to 2399	140
200 to 299	30	1300 to 1399	85	2400 to 2499	145
300 to 399	35	1400 to 1499	90	2500 to 2599	150
400 to 499	40	1500 to 1599	95	2600 to 2699	155
500 to 599	45	1600 to 1699	100	2700 to 2799	160
600 to 699	50	1700 to 1799	105	2800 to 2899	165
700 to 799	55	1800 to 1899	110	2900 to 2999	170
800 to 899	60	1900 to 1999	120	3000 to 3099	175
900 to 999	65	2000 to 2099	125	3100 to 3199	180
1000 to 1099	70	2100 to 2199	130	3200 to 3299	185

As a general rule, set the proportional band to ten percent of the set point below 1000° and five percent of the set point above 1000°. This setting is useful as a starting value.

Integral Settings

The controller's integral parameter is set in seconds per repeat. Some other products use an integral term called reset, in units of repeats per minute. *Table 4.2* shows integral settings versus reset settings.

Table 4.2 Integral Term and Reset Settings

Integral (Seconds/Repeat)	Reset (Repeats/Minute)	Integral (Seconds/Repeat)	Reset (Repeats/Minute)
30	2.0	210	0.28
45	1.3	240	0.25
60	1.0	270	0.22
90	0.66	300	0.20
120	0.50	400	0.15
150	0.40	500	0.12
180	0.33	600	0.10

As a general rule, use 60, 120, 180 or 240 as a starting value for the integral.

Derivative Settings

The controller's derivative parameter is programmed in seconds. Some other products use a derivative term called rate programmed in minutes. Use the table or the formula to convert parameters from one form to the other. *Table 4.3* shows derivative versus rate. Rate = Derivative/60.

Table 4.3 Derivative Term Versus Rate

Derivative (seconds)	Rate (minutes)	Derivative (seconds)	Rate (minutes)
5	0.08	35	0.58
10	0.16	40	0.66
15	0.25	45	0.75
20	0.33	50	0.83
25	0.41	55	0.91
30	0.50	60	1.0

As a general rule, set the derivative to 15 percent of integral as a starting value.

NOTE! ***While the basic PID algorithm is well defined and widely recognized, various controllers implement it differently. Parameters may not be taken from one controller and applied to another with optimum results even if the above unit conversions are performed.***

General PID Constants by Application

This section gives PID values for many applications. They are useful as control values or as *starting* points for PID tuning.

Proportional Band Only (P)

Set the proportional band to seven percent of the set point. (Example: Set point = 450, proportional band = 31).

Proportional with Integral (PI)

- Set the proportional band to ten percent of set point. (Example: Set point = 450, proportional band = 45).
- Set integral to 60.
- Set derivative off.
- Set the output filter to 2.

Proportional and Integral with Derivative (PID)

- Set the proportional band to ten percent of the set point.
  (Example: Set point = 450, proportional band = 45).
- Set the integral to 60.
- Set the derivative to 15 percent of the integral. (Example: Integral = 60, derivative = 9).
- Set the output filter to 2.

Table 4.4 shows general PID constants by application.

Table 4.4 General PID Constants

Application	Proportional Band	Integral	Derivative	Filter	Output Type	Cycle Time	Action
Electrical heat with solid-state relays	50°	60	15	4	DZC	-	Reverse
Electrical heat with electrome-chanical relays	50°	60	15	6	TP	20	Reverse
Cool with sole-noid valve	70°	500	90	4	TP	10	Direct
Cool with fans	10°	Off	10	4	TP	10	Direct
Electric heat with open heat coils	30°	20	Off	4	DZC	-	Reverse
Gas heat with motorized valves	60°	120	25	8	Analog	-	Reverse
Set Point>1200	100°	240	40				

Control Outputs

The controller provides open collector outputs for control. These outputs normally control the process using solid-state relays.

Open collector outputs can be configured to drive a serial digital-to-analog converter (Serial DAC) which, in turn, can provide 0 to 5V⎓ (dc), 0 to 10V⎓ (dc) or 4 to 20 mA control signals to operate field output devices.

Output Control Signals

The following sections explain the different control output signals available.

On/Off

When on/off control is used, the output is on or off depending on the difference between the set point and the process variable. PID algorithms are not used with on/off control. The output variable is always off or on (0 or 100 percent).

Time Proportioning (TP)

With time proportioning outputs, the PID algorithm calculates an output between 0 and 100 percent, which is represented by turning on an output for that percent of a fixed, user-selected time base or cycle time.

The cycle time is the time over which the output is proportioned, and it can be any value from 1 to 255 seconds. For example, if the output is 30 percent and the cycle time is ten seconds, then the output will be on for three seconds and off for seven seconds. *Figure 4.5* shows examples of time proportioning and distributed zero crossing (DZC) waveforms.

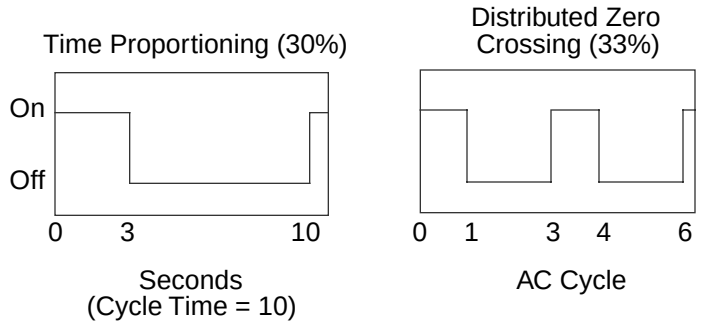


Figure 4.5 Time Proportioning and Distributed Zero Crossing Waveforms

Distributed Zero Crossing (DZC)

With DZC outputs, the PID algorithm calculates an output between 0 and 100 percent, but the output is distributed on a variable time base. For each ac line cycle, the controller decides whether the power should be on or off. There is no fixed cycle time since the decision is made for each line cycle. When used in conjunction with a zero crossing device, such as a solid-state relay (SSR), switching is done only at the zero crossing of the ac line, which helps reduce electrical noise.

Using a DZC output should extend the life of heaters. Since the time period for 60 Hz power is 16.6 ms, the switching interval is very short and the power is applied uniformly. DZC should be used with SSRs. Do not use DZC output for electromechanical relays.

The combination of DZC output and a solid-state relay can inexpensively approach the effect of analog, phase-angle fired control. Note, however, DZC switching does not limit the current and voltage applied to the heater as phase-angle firing does.

Three-Phase Distributed Zero Crossing (3P DZC)

This output type performs exactly the same as DZC except that the minimum switching time is three ac line cycles. This may be advantageous in some applications using three-phase heaters and three-phase power switching.

Analog Outputs

For analog outputs, the PID algorithm calculates an output between 0 and 100 percent. This percentage of the analog output range can be applied to an output device via a Dual DAC or a Serial DAC.

Output Filter

The output filter digitally smooths PID control output signals. It has a range of 0 to 255 scans, which gives a time constant of 0 to 85 seconds for a CPC408 or 0 to 43 seconds for a CPC404. Use the output filter if you need to filter out erratic output swings due to extremely sensitive input signals, like a turbine flow signal or an open air thermocouple in a dry air gas oven.

The output filter can also enhance PID control. Some processes are very sensitive and would otherwise require a large proportional band, making normal control methods ineffective. Using the output filter allows a smaller proportional band to be used, achieving better control.

Also, use the filter to reduce the process output swings and output noise when a large derivative is necessary, or to make badly tuned PID loops and poorly designed processes behave properly.

Reverse and Direct Action

With reverse action an increase in the process variable causes a decrease in the output. Conversely, with direct action an increase in the process variable causes an increase in the output. Heating applications normally use reverse action and cooling applications usually use direct action.

5

Menu and Parameter Reference

The CPC400 has operator and setup parameters that let you change the configuration of the controller. This section contains the following information for each operator and setup parameter:

- Description
- Values
- Default value
- Information for addressing controller parameters using serial communications and LogicPro programs.

For information about how to access the operator and setup parameters, see the Operation and Setup chapter.

Operator Parameters

Use the operator parameters to change the set point, control mode or output power level.

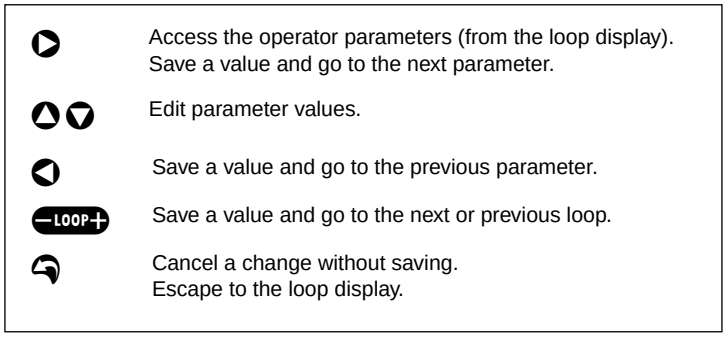
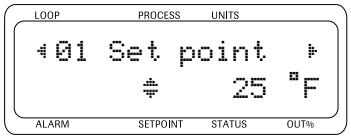


Figure 5.1 Operator Parameter Navigation

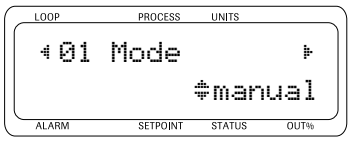
Set Point



Enter the desired value for the process variable. The new set point will take effect immediately when you save the new value. The *Set point* parameter is not available if ratio control or cascade control is enabled for the loop.

Values: For thermocouples and RTD inputs, same as the input range (see *Table 5.7 on page 104*). For process and pulse inputs, any value between the *Input range low* and *Input range high* parameters in the *Input* menu.
Default: 25
Modbus Address (Loops 1 to 9): 40205 to 40213
Parameter Number: 12
LogicPro Driver: Setpoint
LogicPro Address (Loops 1 to 9): 1 to 9
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

Mode



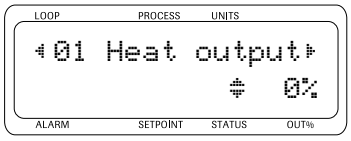
Choose the control mode for this loop.

Values: See *Table 5.1*
Default: *manual* (0)
Modbus Address (Loops 1 to 9): 40120 to 40128
Parameter Number: 7
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 7.1 to 7.9

Table 5.1 Control Mode Menu Options

Display Value	Modbus or LogicPro Value	Description
manual	0	The operator manually sets the output power for the loop.
auto	1	The controller automatically controls the outputs.
tune	2	The controller applies a step change and calculates initial PID parameters for the loop. After the initial tuning, the control mode changes to adapt to fine tune the loop. This mode has no effect with on/off control.
adapt	3	The controller automatically controls the outputs and adjusts the control parameters. This mode has no effect with on/off control. The mode display blinks when set to adapt but the process variable is outside the tune band.

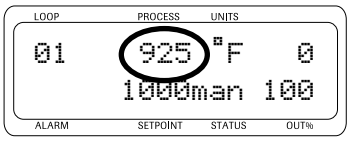
Heat/Cool Output



Choose the manual output power level for this loop. This parameter is available only for the manual control mode.

Values: 0 to 100% (0 to 1000). Values in parentheses are for serial communications and LogicPro.
Default: 0% (0)
Modbus Address (Loops 1 to 9): 40273 to 40281 (heat) or 40290 to 40298 (cool)
Parameter Number: 16 (heat) or 17 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 16.1 to 16.9 (heat) or 17.1 to 17.9 (cool)
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Percentage Values on page 80*.

Process Variable



Indicates the value used for feedback after filtering and scaling. This parameter is read-only.

Values: For thermocouples and RTD inputs, same as the input range (see *Table 5.7 on page 104*). For process and pulse inputs, any value between the *Input range low* and *Input range high* parameters in the *Input* menu.
Modbus Address (Loops 1 to 9): 40222 to 40230
Parameter Number: 13
LogicPro Driver: CPC400_PV
LogicPro Address (Loops 1 to 9): 1 to 9
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

Overview of the Setup Menus

The CPC400 has eleven setup menus. *Table 5.2* provides a brief description of each menu. *Figure 5.2* lists all of the menus and parameters in the same order that they appear in the controller.

Table 5.2 CPC400 Setup Menus

Menu	Description	Page Number
Global setup	Configure global settings, which affect all loops.	96
Input	Configure the input for each loop.	104
Channel	Configure each PV source and Channel Name	109
Control	Configure PID control for each loop.	111
Output	Configure heat and cool outputs for each loop.	116
Alarms	Configure alarms for each loop.	121
PV retrans	Configure process variable retransmit.	125
Cascade	Configure cascade control.	127
Ratio	Configure ratio control.	128
Soft integers	Pass integer data (-32768 to 32767) between a LogicPro logic program and the operator.	130
Soft Booleans	Pass Boolean data (0 or 1) between a LogicPro logic program and the operator.	131
I/O test	Perform tests of the digital inputs, digital outputs and keypad.	131

Global setup
- Load setup from job
- Save setup as job
- BCD job load
- BCD job load logic
- Mode override
- Mode override D/I active
- Logic program
- Power up alarm delay
- Power up loop mode
- Power up with logic
- Keypad lock
- TC short alarm
- Controller address
- Comm baud rate
- Comm parity
- AC line freq
- D/O alarm polarity
- CPC4xx Vx.xxX cs=xxxx

Input
- Input type
- Input units
- Input pulse sample
- Calibration offset
- Reversed T/C detect
- Disp format
- Input range high
- Input high signal
- Input range low
- Input low signal
- Input filter

Channel
- Loop name
- PV Source

Control
- Heat prop band
- Heat integral
- Heat derivative
- Heat manual reset
- Heat filter
- Cool prop band
- Cool integral
- Cool derivative
- Cool manual reset
- Cool filter
- Hysteresis
- RestoreAuto
- Tune band
- Tune gain
- Overshoot reduction
- Control type

Navigation for the Setup Menus

Access the setup menus (press and hold for 3 seconds)
Cancel a change without saving.
Escape from a parameter to a menu.
Escape from a menu to the loop display.

Go to the next or previous menu.
Edit a parameter value.

Save a value and go to the next or previous parameter.

Save a value and go to the next or previous loop.

Output
- Heat output type
- Heat cycle time
- Heat SDAC signal
- Ht SDAC low signal
- Ht SDAC hi signal
- Heat action
- Heat power limit
- HtPwr limit time
- Sensor fail heat output
- Open T/C ht out average
- Heat output curve
- Cool output type
- Cool cycle time
- Cool SDAC signal
- Cl SDAC low signal
- Cl SDAC hi signal
- Cool action
- Cool power limit
- ClPwr limit time
- Sensor fail cool output
- Open T/C cl out average
- Cool output curve

Alarms
- Alarm high SP
- Alarm high func
- Alarm high output
- HiDeviation value
- HiDeviation func
- HiDeviation output
- LoDeviation value
- LoDeviation func
- LoDeviation output
- Alarm low SP
- Alarm low func
- Alarm low output
- Alarm hysteresis
- Alarm delay

PV retrans
- Heat output retrans PV
- Ht retrans LowPV
- Ht retrans HighPV
- Cool output retrans PV
- Cl retrans LowPV
- Cl retrans HighPV

Cascade
- Cascade prim loop
- Cascade low SP
- Cascade hi SP

Ratio
- Ratio master loop
- Ratio low SP
- Ratio high SP
- Control ratio
- Ratio SP diff

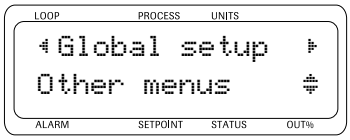
Soft integers
- Soft int 1 value
- ...
- Soft int 1100 value

Soft Booleans
- Soft Bool 1 value
- ...
- Soft Bool 256 value

I/O tests
- Digital inputs
- Keypad test
- Test D/O 1
- ...
- Test D/O 35

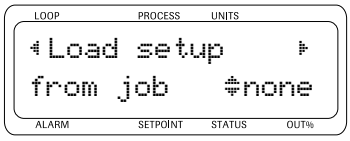
Figure 5.2 Setup Menus and Parameters

Global Setup Menu



Use the *Global setup* menu to set parameters that affect all loops.

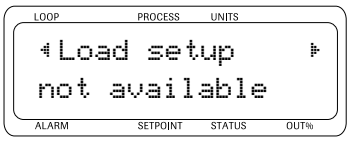
Load Setup From Job



Load one of the jobs stored in battery-backed RAM. The following parameters are loaded for each loop as part of a job:

- PID constants, filter settings, set points and hysteresis.
- Control mode (automatic or manual) and output power levels (if the loop is in manual control)
- Alarm functions, set points, hysteresis and delay settings.
- Soft integers 81 to 100 and soft Booleans 237 to 256.

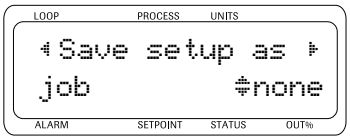
If you have enabled remote job selection (see *BCD Job Load on page 97*), you will see the message below, and you will not be able to use the controller keypad to load a job.



NOTE! ***Current settings are overwritten when you select a job from memory. Save your current settings to another job number if you want to keep them.***

Values: 1 to 8 (1 to 8) or *none* (0). Values in parentheses are for serial communications and LogicPro.
Default: *none* (0)
Modbus Address: 44836
Parameter Number: 111
LogicPro Driver: Database
LogicPro Address: 111.1

Save Setup as Job

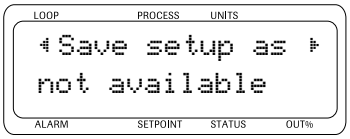


Save the current settings as one of eight jobs in the battery-backed RAM. The following parameters are saved for each loop as part of a job:

- PID constants, filter settings, set points and hysteresis.
- Control mode (automatic or manual) and output power levels (if the loop is in manual control)

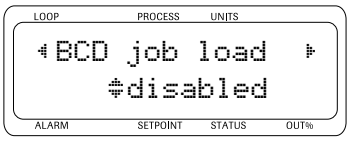
- Alarm functions, set points, hysteresis and delay settings.
- Soft integers 81 to 100 and soft Booleans 237 to 256.

If you have enabled remote job selection (see *BCD Job Load on page 97*), you will see the message below, and you will not be able to use the controller keypad to save a job.



Values: 1 to 8 (1 to 8) or *none* (0). Values in parentheses are for serial communications and LogicPro.
Default: *none* (0)
Modbus Address: 44835
Parameter Number: 110
LogicPro Driver: Database
LogicPro Address: 110.1

BCD Job Load



Choose the digital input(s) to use for remote job selection. The controller uses the states of the selected inputs as a binary code that specifies which job number to run (see *Table 5.3*).

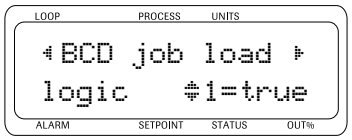
To save jobs into memory, use the *Save setup as job* parameter.

Values: See *Table 5.3*
Default: *disabled* (0)
Modbus Address: 44837
Parameter Number: 112
LogicPro Driver: Database
LogicPro Address: 112.1

Table 5.3 Values for BCD Job Load

Display Value	Modbus or LogicPro Value	Description
use D/I 1	1	Use digital input 1 for remote selection of jobs 1 and 2.
use D/I 1-2	2	Use digital inputs 1 and 2 for remote selection of jobs 1 to 4.
use D/I 1-3	3	Use digital inputs 1 to 3 for remote selection of jobs 1 to 8.
disabled	0	Disable remote job selection

BCD Job Load Logic



Choose which state is considered "true" for the digital inputs that are used for remote job selection.

- If *1=true* is selected, then an input is true if connected to controller common, and false for an open circuit.
- If *0=true* is selected, then an input is true for an open circuit, and false if connected to controller common.

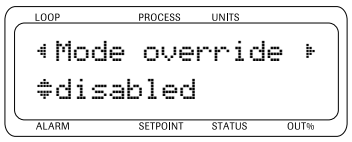
Table 5.4 shows which combinations of input states are required to load each job.

Values: *1=true* (0) or *0=true* (1). Values in parentheses are for serial communications and LogicPro.
Default: *1=true* (0)
Modbus Address: 44838
Parameter Number: 113
LogicPro Driver: Database
LogicPro Address: 113.1

Table 5.4 Digital Input States Required to Load Each Job

Job	Digital Input		
	1	2	3
1	F	F	F
2	T	F	F
3	F	T	F
4	T	T	F
5	F	F	T
6	T	F	T
7	F	T	T
8	T	T	T

Mode Override



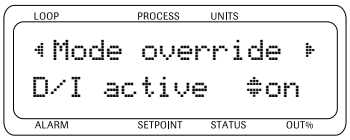
Choose the digital input to use for the mode override feature. When the input is activated, the controller sets all loops to manual mode at the output levels specified at the *Sensor fail heat output* and *Sensor fail cool output* parameters in the *Output* menu.

Use the *Mode override D/I active* parameter to choose which signal state activates the mode override feature.

Values: *enabled by D/I1* to *enabled by D/I8* (1 to 8) or *disabled* (0). Values in parentheses are for serial communications and LogicPro.
Default: *disabled* (0)
Modbus Address: 44839
Parameter Number: 114
LogicPro Driver: Database
LogicPro Address: 114.1

WARNING! ***Do not rely solely on the mode override feature to shut down your process. Install external safety devices or overtemperature devices for emergency shutdowns.***

Mode Override Digital Input Active

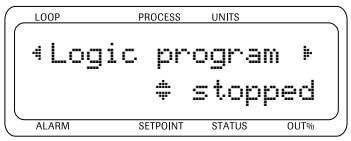


Choose whether the on state (connected to controller common) or off state (open circuit) activates the mode override feature.

Use the *Mode override* parameter to enable the mode override feature and select the digital input.

Values: *on* (0) or *off* (1). Values in parentheses are for serial communications and LogicPro.
Default: *on* (0)
Modbus Address: 44840
Parameter Number: 115
LogicPro Driver: Database
LogicPro Address: 115.1

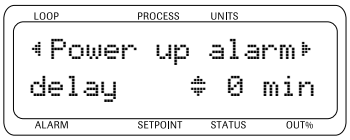
Logic Program



This parameter indicates whether a logic program is running. You can also use this parameter to run or stop a logic program.

Values: *running* (1) or *stopped* (0). Values in parentheses are for serial communications and LogicPro.
Default: *stopped* (0)
Modbus Address: 49481
Parameter Number: 150
LogicPro Driver: Database
LogicPro Address: 150.1

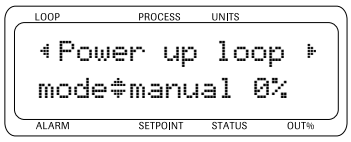
Power Up Alarm Delay



Specify how long to delay high, low and deviation alarms on all loops during powerup. This feature does not delay failed sensor alarms.

Values: 0 to 60 minutes
Default: 0
Modbus Address: 40409
Parameter Number: 24
LogicPro Driver: Database
LogicPro Address: 24.1

Power Up Loop Mode



Choose the power-up state of the control outputs.

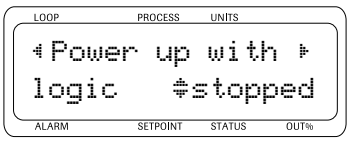
Values: See *Table 5.5*. For serial communications and LogicPro, this is a bit-wise parameter stored as the first bit of the system command word, so set or read only that bit.
Default: *manual 0%* (0)
Modbus Address: 49790, first bit
Parameter Number: 49
LogicPro Driver: Database
LogicPro Address: 49.1, first bit

WARNING! ***Do not set the controller to start from memory if it might be unsafe for the control outputs to be on upon power up.***

Table 5.5 Power Up Loop Modes

Display Value	Modbus or LogicPro Value	Description
manual 0%	0	Upon powerup, all loops are set to manual mode at 0 percent output.
from memory	1	Upon powerup, all loops are restored to the previous control mode and output power level.

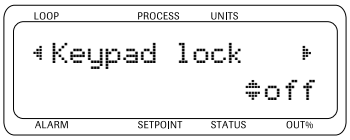
Power Up With Logic



If you are using a logic program, choose whether it should run automatically upon powerup of the controller.

Values: *stopped* (0) or *running* (1). Values in parentheses are for serial communications and LogicPro.
Default: *stopped* (0)
Modbus Address: 45308
Parameter Number: 131
LogicPro Driver: Database
LogicPro Address: 131.1

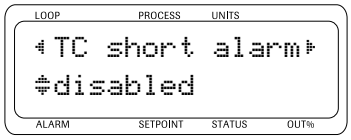
Keypad Lock



Set this parameter to *on* to disable the ◐ key on the keypad. This restricts access to the operator parameters from the controller keypad.

Values: *on* (1) or *off* (0). Values in parentheses are for serial communications and LogicPro, and are stored as the second bit of the system command word, so set or read only that bit.
Default: *off* (0)
Modbus Address: 40790, second bit
Parameter Number: 49
LogicPro Driver: Database
LogicPro Address: 49.1, second bit

Thermocouple Short Alarm

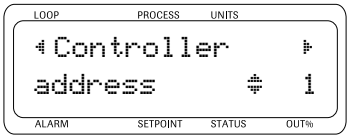


Choose a digital input to enable for thermocouple short detection. Install a device that connects the input to controller common when the process power is on. A thermocouple short is detected if the process power is on but the temperature does not rise as expected.

If a thermocouple short is detected, the controller puts the loop in manual mode at the output power level specified by the *Sensor fail heat output* or *Sensor fail cool output* parameter in the *Output* menu.

Values: *enabled by D/I1* to *enabled by D/I8* (1 to 8) or *disabled* (0). Values in parentheses are for serial communications and LogicPro.
Default: *disabled* (0)
Modbus Address: 44842
Parameter Number: 117
LogicPro Driver: Database
LogicPro Address: 117.1

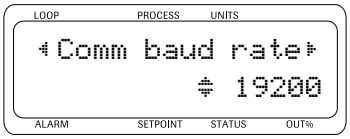
Controller Address



Choose the communications address for this controller. On an EIA/TIA-485 communication loop, each controller must have a unique address. Begin with address *1* for the first controller and assign each subsequent controller the next higher address.

Values: 1 to 247
Default: 1
Modbus Address: 44843
Parameter Number: 118
LogicPro Driver: Database
LogicPro Address: 118.1

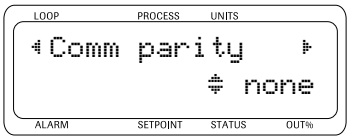
Communications Baud Rate



Choose the baud rate for serial communications. Choose the same baud rate for both the controller and the HMI software or operator interface panel.

Values: *2400* (1), *9600* (0) or *19200* (2). Values in parentheses are for serial communications and LogicPro.
Default: *19200* (2)
Modbus Address: 44844
Parameter Number: 119
LogicPro Driver: Database
LogicPro Address: 119.1

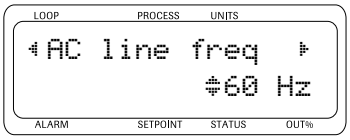
Communications Parity



Choose the parity for serial communications.

Values: *none* (0), *even* (1) or *odd* (2). Values in parentheses are for serial communications and LogicPro.
Default: *none* (0)
Modbus Address: 44847
Parameter Number: 122
LogicPro Driver: Database
LogicPro Address: 122.1

AC Line Frequency



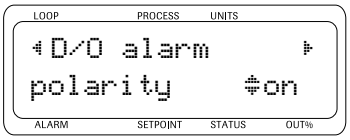
Specify the ac line frequency. The controller uses this information for correct timing of distributed zero-crossing (DZC) output signals and for optimum filtering of analog inputs.

If you edit this parameter, you must switch power to the controller off, then back on, in order for the change take effect.

Values: 50 (1) or 60 (0) Hz. Values in parentheses are for serial communications and LogicPro, and are stored as the third bit of the system command word, so set or read only that bit.

Default: 60 Hz (0)
Modbus Address: 40790, third bit
Parameter Number: 49
LogicPro Driver: Database
LogicPro Address: 49.1, third bit

Digital Output Alarm Polarity



Choose the polarity of all digital outputs used for alarms.

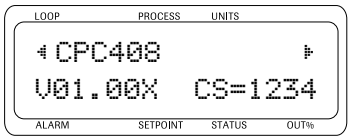
This setting does *not* apply to the global alarm output or the CPU watchdog output.

Values: See *Table 5.6*. For serial communications and LogicPro, this parameter is stored as the fifth bit of the system command word, so set or read only that bit.
Default: *on* (0)
Modbus Address: 40790, fifth bit
Parameter Number: 49
LogicPro Driver: Database
LogicPro Address: 49.1, fifth bit

Table 5.6 Digital Output Alarm Polarity

Display Value	Modbus or Logic Value	Description
on	0	Digital alarm outputs sink current to analog common when an alarm occurs.
off	1	Digital alarm outputs stop sinking current to analog common when an alarm occurs.

Model and Firmware Version

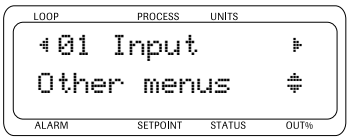


The last parameter in the *Global setup* menu shows the controller model (CPC404 or CPC408), the firmware version (Vxx.xxX), and the flash-memory checksum (CS=xxxx).

To retrieve the firmware version through serial communications or LogicPro, see *Firmware Version on page 135*.

NOTE! ***The checksum is not affected by loading or changing a logic program. The checksum is determined only by the content of the closed-loop control program.***

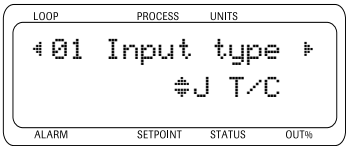
Input Menu



Use the *Input* menu to configure the process input:

- Input type
- Engineering units
- Scaling, calibration and filtering.

Input Type



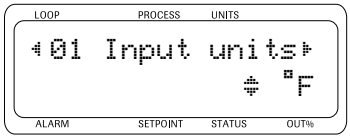
Choose the type of sensor that is connected to the analog input.

Values: See *Table 5.7*. For the pulse loop (CPC404 loop 5 or CPC408 loop 9), the only choices are *pulse* (7) and *skip* (10).
Default: *J T/C* (1); for the pulse loop, *pulse* (7)
Modbus Address (Loops 1 to 9): 40103 to 40111
Parameter Number: 6
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 6.1 to 6.9

Table 5.7 Input Types and Ranges

Display Value	Modbus or Logic Value	Description	Input Range
J T/C	1	Type J thermocouple	-350 to 1400°F (-212 to 760°C)
K T/C	2	Type K thermocouple	-450 to 2500°F (-268 to 1371°C)
T T/C	3	Type T thermocouple	-450 to 750°F (-268 to 399°C)
S T/C	4	Type S thermocouple	0 to 3200°F (-18 to 1760°C)
R T/C	5	Type R thermocouple	0 to 3210°F (-18 to 1766°C)
B T/C	6	Type B thermocouple	150 to 3200°F (66 to 1760°C)
E T/C	20	Type E thermocouple	-328 to 1448°F (-200 to 787°C)
RTD	8	RTD	-328.0 to 1150.0°F (-200.0 to 621.1°C)
process	0	Voltage or current signal, depending upon the hardware configuration. See *Figure 1.2 on page 6*.	User defined. See *Setting Up Process Variable Retransmit on page 67*.
pulse	7	Pulse input. Available only for loop 5 on the CPC404 or loop 9 on the CPC408.	0 to 2000 Hz, scalable
skip	10	Loop is not used for control, does not report alarms, and is not shown on the scanning display.	(none)

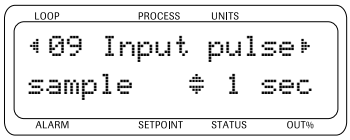
Input Units



For a thermocouple or RTD input, choose the temperature scale. For a process or pulse input, enter a three-character description of the engineering units.

Values: For a process or pulse input, see *Table 5.10*. For a thermocouple or RTD input, *°F* or *°C*. When setting the units for a thermocouple or RTD input through serial communications or LogicPro, you must set the first character as a space (32), the second character as the degree symbol (223) and the third character as "C" (67) or "F" (70).
Default: *°F* for a thermocouple or RTD input, *HZ* for a pulse input, three spaces for a process input
Modbus Address: 40792, 40793 and 40794 for loop 1; 40795, 40796 and 40797 for loop 2; and so on.
Parameter Number: 51
LogicPro Driver: Database
LogicPro Address: 51.1, 51.2 and 51.3 for loop 1; 51.4, 51.5 and 51.6 for loop 2; and so on.

Input Pulse Sample

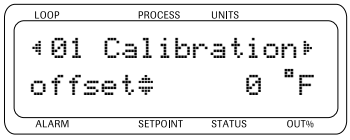


For a pulse input, enter the sample period over which pulses are counted. Each sample period, the controller divides the number of pulses by the sample time. The controller scales the result and uses it as the process variable for the pulse loop.

Generally, the longer the pulse sample time, the more stable the process variable, but the slower the response of the loop.

Values: 1 to 20 seconds
Default: 1 second
Modbus Address: 40580
Parameter Number: 35
LogicPro Driver: Database
LogicPro Address: 35.1

Calibration Offset



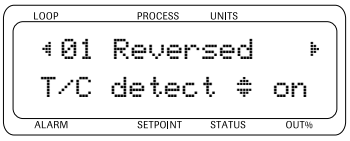
For a thermocouple or RTD input, enter the offset to correct for signal inaccuracy. A positive value increases the reading and a negative value decreases it. Use an independent sensor or your own calibration equipment to find the offset for your system.

Values: See *Table 5.8*
Default: 0 or 0.0
Modbus Address (Loops 1 to 8): 40649 to 40656
Parameter Number: 40
LogicPro Driver: Database
LogicPro Address (Loops 1 to 8): 40.1 to 40.8
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

Table 5.8 Calibration Offset Ranges

Type of Sensor	Offset Range	
	˚F	˚C
RTD	-300.0 to 300.0	-300.0 to 300.0
J Thermocouple K Thermocouple T Thermocouple	-300 to 300	-300 to 300
B Thermocouple S Thermocouple	-300 to 76	-300 to 300
R Thermocouple	-300 to 66	-300 to 300

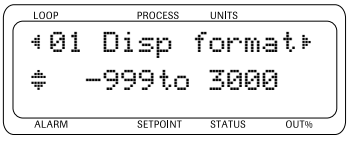
Reversed Thermocouple Detection



Choose whether to enable polarity checking for thermocouples. If the controller detects a reversed thermocouple, it activates an alarm and sets the loop to manual mode at the power level indicated by the *Sensor fail heat output* or *Sensor fail cool output* parameter in the *Output* menu.

Values: *on* (1) or *off* (0). Values in parentheses are for serial communications and LogicPro, and are stored as the first bit of the word at this address, so set or read only that bit.
Default: *on* (1)
Modbus Address (Loops 1 to 8): 44443 to 44450, first bit
Parameter Number: 86
LogicPro Driver: Database
LogicPro Address (Loops 1 to 8): 86.1 to 86.8, first bit

Display Format



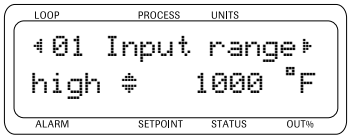
For a process or pulse input, choose the range and the number of decimal places for the process variable and related parameters. Choose a precision appropriate for the range and accuracy of the sensor.

Values: See *Table 5.9*
Default: *-999 to 3000* for a process input, *-9999 to 30000* for a pulse input
Modbus Address (Loops 1 to 9): 40666 to 40674
Parameter Number: 41
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 41.1 to 41.9

Table 5.9 Display Formats

Display Value	Modbus or LogicPro Value	Minimum Process Variable	Maximum Process Variable
-999 to 3000	255	-999	3000
-9999 to 30000	0	-9999	30000
-999.9 to 3000.0	1	-999.9	3000.0
-99.99 to 300.00	2	-99.99	300.00
-9.999 to 30.000	3	-9.999	30.000
-.9999 to 3.0000	4	-0.9999	3.0000

Input Range High

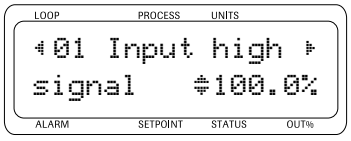


For a process or pulse input, enter the high process variable for input scaling purposes. This value will be displayed when the input signal is at the level set for *Input high signal*.

This parameter and the *Input high signal* parameter together define a point on the conversion line for the scaling function. See *Setting Up a Process or Pulse Input on page 58*.

Values: Any value between *Input range low* and the maximum process variable for the selected display format (see *Table 5.9*).
Default: 1000. Decimal placement depends upon the value of the *Disp format* parameter.
Modbus Address (Loops 1 to 9): 40581 to 40589
Parameter Number: 36
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 36.1 to 36.9
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

Input High Signal

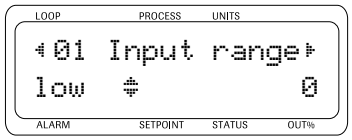


For a process or pulse input, enter the input signal level that corresponds to the value for the *Input range high* parameter. For a process input, the high signal is a percentage of the full scale input range. For a pulse input, the high signal is expressed in Hertz.

Values: For process inputs, -99.8 to 999.9 (-998 to 9999) percent of full scale. For pulse inputs, 1 to 2000 (1 to 2000) Hz. This value must be greater than the value for *Input low signal*. Values in parentheses are for serial communications and LogicPro.
Default: 100.0% (1000) for a process input, 1000 (1000) for a pulse input

Modbus Address (Loops 1 to 9): 40615 to 40623
Parameter Number: 38
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 38.1 to 38.9
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Percentage Values on page 80*.

Input Range Low

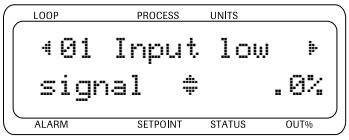


For a process or pulse input, enter the low process variable for input scaling purposes. This value will be displayed when the input signal is at the level set for *Input low signal*.

This value and the value for *Input low signal* together define one of the points on the scaling function's conversion line. See *Setting Up a Process or Pulse Input on page 58*.

Values: Any value between the minimum process variable for the selected display format (see *Table 5.9 on page 107*) and the value for *Input range high*.
Default: 0
Modbus Address (Loops 1 to 9): 40598 to 40606
Parameter Number: 37
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 37.1 to 37.9
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

Input Low Signal

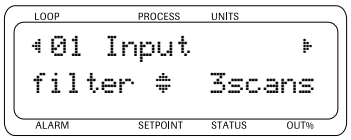


For a process or pulse input, enter the input signal level that corresponds to the low process variable you entered for the *Input range low* parameter.

For a process input, the low signal is a percentage of the full scale input range. For a pulse input, the high signal is expressed in Hertz.

Values: For process inputs, -99.9 to 999.8 (-999 to 9998) percent of full scale. For pulse inputs, 0 to 1999 (0 to 1999) Hz. This value must be less than the value for *Input high signal*. Values in parenthesis are for serial communications and LogicPro.
Default: 0
Modbus Address (Loops 1 to 9): 40632 to 40640
Parameter Number: 39
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 39.1 to 39.9
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Percentage Values on page 80*.

Input Filter

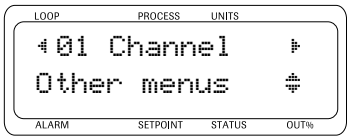


Choose the amount of filtering to apply to the process variable before the value is logged, displayed or used in the control calculation. The input filter simulates a resistor-capacitor (RC) filter. Use it to keep the process variable from varying unrealistically.

When enabled, the process variable responds to a step change by going to two-thirds of the actual value within the specified number of scans. One scan is 0.17 seconds for a CPC404 and 0.33 seconds for a CPC408.

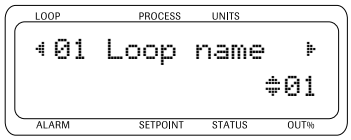
Values: 0 (off) to 255
Default: 3
Modbus Address (Loops 1 to 9): 44409 to 44417
Parameter Number: 84
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 84.1 to 84.9

Channel Menu



Use the *Channel* menu to name and select the feedback for the loop.

Loop Name



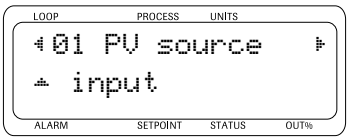
Enter a two-character name for the loop. This name is shown on the controller display in place of the loop number.

Values: See *Table 5.10*.
Default: The loop number (*01*, *02*, *03*, and so on.)
Modbus Address: 45309 and 45310 for loop 1, 45311 and 45312 for loop 2, and so on
Parameter Number: 132
LogicPro Driver: Database
LogicPro Address: 132.1 and 132.2 for loop 1, 132.3 and 132.4 for loop 2, and so on.

Table 5.10 Characters for the Loop Name and Input Units Parameters

Character	Display Values	ASCII Values
A to Z	A to Z	65 to 90
0 to 9	0 to 9	48 to 57
Degree symbol	°	223
Percent sign	%	37
Forward slash	/	47
Space	.	32
Pound sign	#	35

PV Source



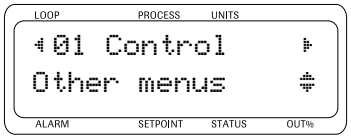
Select whether an analog input or a soft integer is used for the channel's feedback. When it is desirable to control based on a value that is set by logic, for example an average of two or more analog inputs, set the loop to take its feedback from a soft integer, and create a logic program to write the desired value to the soft integer.

Table 5.11 PV Source Options

Display Value	Modbus or LogicPro Value	Description
input n	0	PV Source is the analog input corresponding to the loop number.
soft integer n	1	PV Source is the soft integer corresponding to the loop number.

Values: input n (0) or soft integer n (1). Where n is the channel number.
Default: input n (0)
Modbus Address: 45394 to 45411
Parameter: 136
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 136.1 to 136.9

Control Menu



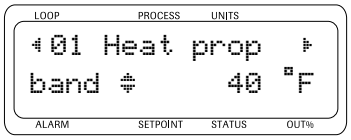
Use the *Control* menu to adjust heat and cool control parameters, including:

- Proportional band, integral and derivative
- Output filter
- Control hysteresis

The controller has separate PID and filter settings for heat and cool outputs. In this section, only the heat screens are shown, but the explanations apply to both the heat and cool parameters.

If you have not set up a CPC400 series controller before, or if you do not know which values to enter, read the Tuning and Control chapter, which contains PID tuning constants and useful starting values.

Heat/Cool Proportional Band



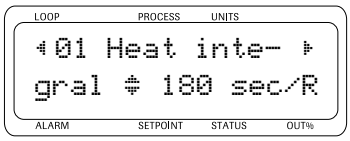
Enter the proportional band. A larger value yields less proportional action for a given deviation from set point.

Values: For a thermocouple or RTD input, see *Table 5.12*. For a process or pulse input, 1 to the span of the input range (*Input range high - Input range low*).
Default: 40 for a thermocouple, RTD or process input; 100 for a pulse input.
Modbus Address (Loops 1 to 9): 40001 to 40009 (heat) or 40018 to 40026 (cool)
Parameter Number: 0 (heat) or 1 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 0.1 to 0.9 (heat) or 1.1 to 1.9 (cool)
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

Table 5.12 Proportional Band Values

Type of Sensor	Values in ˚F	Values in ˚C
J Thermocouple	1 to 1750	1 to 972
K Thermocouple	1 to 2950	1 to 1639
T Thermocouple	1 to 1200	1 to 667
S Thermocouple	1 to 3200	1 to 1778
R Thermocouple	1 to 3210	1 to 1784
B Thermocouple	1 to 3350	1 to 1694
E Thermocouple	1 to 1776	1 to 987
RTD	0.1 to 1478.0	0.1 to 821.1

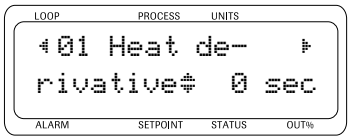
Heat/Cool Integral



Enter the integral constant. A larger value yields less integral action.

Values: 0 (off) to 6000 seconds per repeat
Default: For the *Heat integral* parameter, 180 (or 0 for a pulse input). For the *Cool integral* parameter, 60 (or 0 for a pulse input).
Modbus Address (Loops 1 to 9): 40035 to 40043 (heat) or 40052 to 40060 (cool)
Parameter Number: 2 (heat) or 3 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 2.1 to 2.9 (heat) or 3.1 to 3.9 (cool)

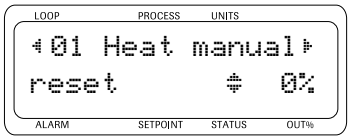
Heat/Cool Derivative



Enter the derivative constant. A larger value yields greater derivative action.

Values: 0 to 255 seconds
Default: 0
Modbus Address (Loops 1 to 9): 40069 to 40077 (heat) or 40086 to 40094 (cool)
Parameter Number: 4 (heat) or 5 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 4.1 to 4.9 (heat) or 5.1 to 5.9 (cool)

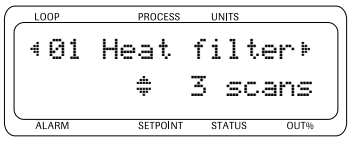
Heat/Cool Manual Reset



A process that uses only proportional control settles at a point above or below the set point; it never reaches the set point. This is known as *offset* or *droop*. At this parameter, enter the power level required to maintain set point to compensate for this offset.

Values: 0 to 100% (0 to 1000). Values in parentheses are for serial communications and LogicPro.
Default: 0% (0)
Modbus Address (Loops 1 to 9): 45274 to 45282 (heat) or 45291 to 45299 (cool)
Parameter Number: 129 (heat) or 130 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 129.1 to 129.9 (heat) or 130.1 to 130.9 (cool)
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Percentage Values on page 80*.

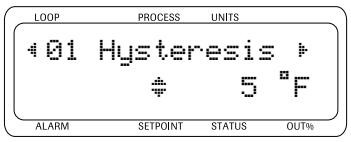
Heat/Cool Filter



Use this parameter to dampen the response of the heat or cool output. The output responds to a change by going to approximately two-thirds of its final value within the specified number of scans. A larger value results in a slower response to changes in the process variable.

Values: 0 (off) to 255
Default: 3
Modbus Address (Loops 1 to 9): 40239 to 40247 (heat) or 40256 to 40264 (cool)
Parameter Number: 14 (heat) or 15 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 14.1 to 14.9 (heat) or 15.1 to 15.9 (cool)

Hysteresis



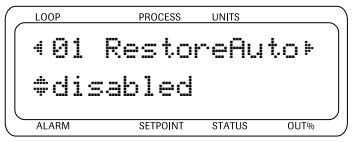
Specify how much the process variable must deviate from set point before the output can switch between on and off (for on/off control) or switch between heating and cooling (for heat/cool control).

Values: See *Table 5.13* for values and decimal placement.
Default: See *Table 5.13*
Modbus Address (Loops 1 to 9): 40856 to 40864
Parameter Number: 54
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 54.1 to 54.9
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

Table 5.13 Values for the Control Hysteresis and Deviation Alarm Parameters

Input Type	Display Format	Values	Default
Thermocouple	n/a	0 to 500	5
RTD	n/a	0 to 500.0	5.0
Process or Pulse	-999 to 3000	0 to 500	5
	-9999 to 30000	0 to 5000	50
	-999.9 to 3000.0	0.0 to 500.0	5.0
	-99.99 to 300.00	0.00 to 50.00	0.50
	-9.999 to 30.000	0.000 to 5.000	0.050
	-0.9999 to 3.0000	0.0000 to 0.5000	0.0050

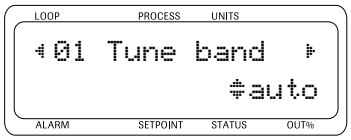
Restore Automatic Mode



Choose a digital input. If the input is connected to controller common, the loop returns to automatic control mode after a failed sensor is repaired (if it was in automatic mode and the digital input was on when the sensor failure occurred).

Values: *enabled by D/I1* to *enabled by D/I8* (1 to 8) or *disabled* (0). Values in parentheses are for serial communications and LogicPro.
Default: *disabled* (0)
Modbus Address (Loops 1 to 9): 44460 to 44468
Parameter Number: 87
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 87.1 to 87.9

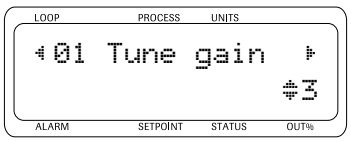
Tune Band



Set the controller to automatically adjust the range around set point over which the controller will continuously tune the control parameters, or enter a fixed value. This parameter is provided for use only in the unlikely event that the controller is unable to automatically tune and stabilize at set point. This may occur with very fast processes. In that case set the Tune Band to a large value such as 300. Otherwise, leave this parameter set to auto.

Values: auto (0) and 1 (1) to 999 (999)
Default: auto (0)
Modbus Address (Loops 1 to 9): 46542 to 46550
Parameter Number: 144
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 144.1 to 144.9

Tune Gain



Choose the target responsiveness of the control algorithm. There are six settings ranging from 1, with the least aggressive response and least potential overshoot (lowest gain), to 6, with the most aggressive response and most potential for overshoot (highest gain). The default setting, 3, is recommended for loops with thermocouple feedback and moderate response and overshoot potential.

Values: 1 (1) to 6 (6)
Default: 3 (3)
Modbus Address (Loops 1 to 9): 46559 to 46567
Parameter Number: 145
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 145.1 to 145.9

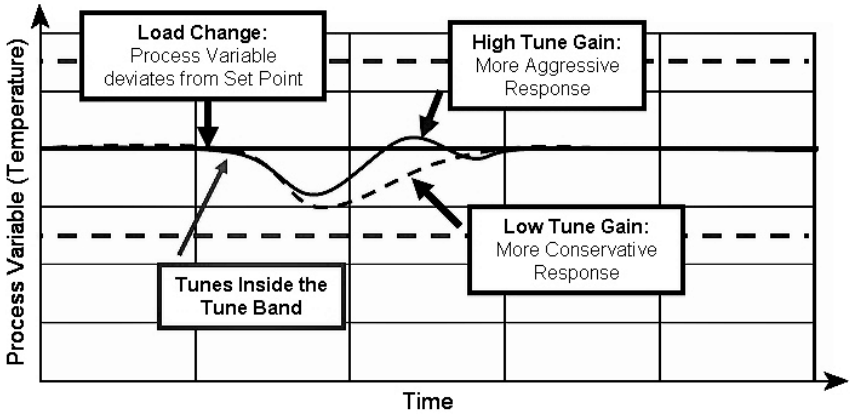
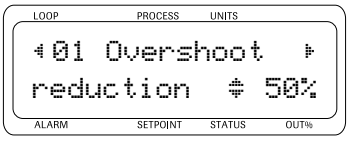


Figure 5.3 The Effect of Tune Gain on Recovery from a Load Change

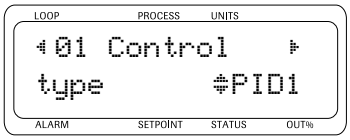
Overshoot Reduction



Enter the amount of overshoot reduction. A larger value yields less overshoot.

Values: 0% (0) to 100% (100)
Default: 50% (50)
Modbus Address (Loops 1 to 9): 46576 to 46584
Parameter Number: 146
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 146.1 to 146.9

Control Type



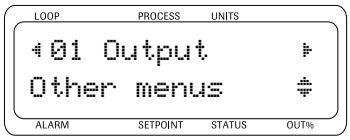
Choose a control algorithm.

Table 5.14 Control Types

Control Type	Description
PID1	Heat and cool outputs used to control. Only one output may be on at a time.
PID2	Heat and cool outputs used to control. Both outputs can be on at the same time.

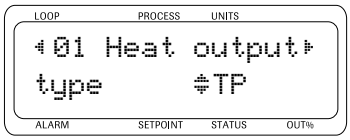
Values: *PID1* (0) or *PID2* (1)
Default: *PID1* (0)
Modbus Address (Loops 1 to 9): 45480 to 45489
Parameter Number: 139
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 139.1 to 139.9

Output Menu



Use the *Output* menu to enable and configure heat and cool outputs.

Heat/Cool Output Type



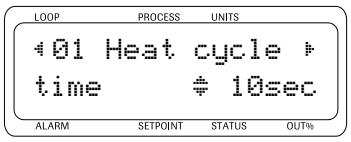
Choose the output type, or disable the heat or cool output. For more information about each output type, see the Tuning and Control chapter. (If an output is used for process variable retransmit, the *disabled* option is not available. To disable the output, first disable process variable retransmit for the output. See *Heat/Cool Output Retransmit on page 126*.)

Values: See *Table 5.15*
Default: *TP* (2) for heat, *disabled* (0) for cool
Modbus Address (Loops 1 to 9): 40137 to 40145 (heat) or 40154 to 40162 (cool)
Parameter Number: 8 (heat) or 9 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 8.1 to 8.9 (heat) or 9.1 to 9.9 (cool)

Table 5.15 Heat and Cool Output Types

Output Type	Display Value	Modbus or LogicPro Value	Description
Time Proportioning	TP	2	The output is switched on and off once during a user-selected cycle time. Within each cycle, the duration of on versus off time is proportional to the percent output power.
On/Off	on/off	1	The output is either full on or full off.
None	disabled	0	The output is not used for control and is available for another use, such as an alarm output.
Three-Phase Distributed Zero Crossing	3P DZC	5	Same as *DZC*, but for three-phase heaters wired in delta configuration. For grounded Y configuration, use DZC instead.
Serial DAC	SDAC	4	Use this option if a Serial DAC is connected to the output. If you set the output type to *SDAC*, the controller assigns digital output 34 as a clock line for the Serial DAC.
Distributed Zero Crossing	DZC	3	The output on/off state is calculated for every ac line cycle, which means that the output turns on and off multiple times per second. Use *DZC* with solid-state output devices or a Dual DAC. Not recommended for use with electromechanical relays.

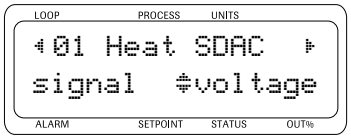
Heat/Cool Cycle Time



For a time-proportioning output, enter the cycle time in seconds. For more information about cycle time, see *Time Proportioning (TP) on page 88*.

Values: 1 to 255 seconds
Default: 10 for a heat output, 10 for a cool output
Modbus Address (Loops 1 to 9): 40683 to 40691 (heat) or 40700 to 40708 (cool)
Parameter Number: 42 (heat) or 43 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 42.1 to 42.9 (heat) or 43.1 to 43.9 (cool)

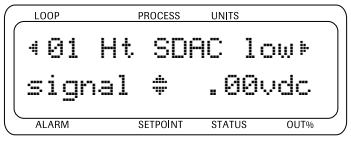
Heat/Cool SDAC Signal



For a Serial DAC output, choose the type of output signal that the Serial DAC will provide.

Values: *voltage* (0) or *current* (1). Values in parentheses are for serial communications and LogicPro.
Default: *voltage* (0)
Modbus Address (Loops 1 to 9): 44307 to 44315 (heat) or 44324 to 44332 (cool)
Parameter Number: 78 (heat) or 79 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 78.1 to 78.9 (heat) or 79.1 to 79.9 (cool)

Heat/Cool SDAC Low Signal

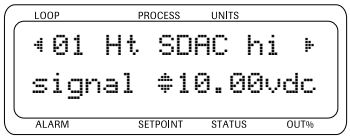


For a Serial DAC output, enter the low output signal level for the Serial DAC. The Serial DAC converts 0 percent output from the controller to this value.

Enter high and low values that match the input range of the output device. For instance, if the output device has a 0 to 10V⎓ (dc) input range, then set *SDAC low signal* to *.00V⎓ (dc)* and set *SDAC hi signal* to *10.00V⎓ (dc)*.

Values: .00 to 9.90V⎓ (dc) (0 to 990) or 0.00 to 19.90 mA (0 to 1990). This value must be less than the value of *SDAC hi signal*. Values in parentheses are for serial communications and LogicPro.
Default: .00V⎓ (dc) (0) or 4.00 mA (400)
Modbus Address (Loops 1 to 9): 44341 to 44349 (heat) or 44358 to 44366 (cool)
Parameter Number: 80 (heat) or 81 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 80.1 to 80.9 (heat) or 81.1 to 81.9 (cool)

Heat/Cool SDAC High Signal

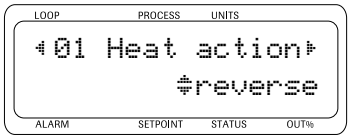


For a Serial DAC output, enter the high output signal level for the Serial DAC. The Serial DAC converts 100 percent output from the controller to the value set here.

Enter the high and low values that match the input range of the output device. For instance, if the output device has a 4 to 20 mA input range, then set *SDAC hi signal* to *20 mA* and set *SDAC low signal* to *4 mA*.

Values: 0.10 to 10.00V⎓ (dc) (10 to 1000) or 0.10 to 20.00 mA (10 to 2000) This value must be greater than the value of *SDAC low signal*. Values in parentheses are for serial communications or LogicPro.
Default: 10.00V⎓ (dc) (1000) or 20.00 mA (2000)
Modbus Address (Loops 1 to 9): 44375 to 44383 (heat) or 44392 to 44400 (cool)
Parameter Number: 82 (heat) or 83 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 82.1 to 82.9 (heat) or 83.1 to 83.9 (cool)

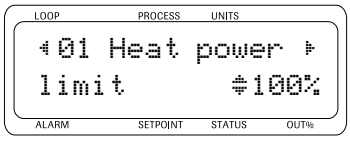
Heat/Cool Action



Choose the control action for the output. When the action is set to *reverse*, the output goes up when the process variable goes down. When the action is set to *direct*, the output goes down when the process variable goes down. Normally, heat outputs are set to reverse action and cool outputs are set to direct action.

Values: *reverse* (0) or *direct* (1). Values in parentheses are for serial communications and LogicPro.
Default: *reverse* (0) for heat outputs, *direct* (1) for cool outputs
Modbus Address (Loops 1 to 9): 40171 to 40179 (heat) or 40188 to 40196 (cool)
Parameter Number: 10 (heat) or 11 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 10.1 to 10.9 (heat) or 11.1 to 11.9 (cool)

Heat/Cool Power Limit



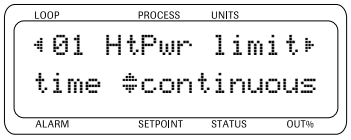
Use this parameter to limit the output power for a heat or cool output. This limit may be continuous, or it may be in effect for the number of minutes specified at the next parameter.

The power limit only affects loops in automatic mode. It does not affect loops in manual mode.

Values: 0 to 100% (0 to 1000). Values in parentheses are for serial communications and LogicPro.
Default: 100% (1000)
Modbus Address (Loops 1 to 9): 44171 to 44179 (heat) or

44188 to 44196 (cool)
Parameter Number: 70 (heat) or 71 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 70.1 to 70.9 (heat) or 71.1 to 71.9 (cool)
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Percentage Values on page 80*.

Heat/Cool Power Limit Time

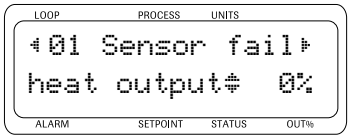


Enter the duration of the power limit set at the previous parameter, or choose *continuous* to keep the limit in effect at all times.

If you choose a timed limit, the limit timer restarts whenever the controller powers up and whenever the loop switches from manual to automatic mode.

Values: 1 to 999 minutes (1 to 999) or *continuous* (0). Values in parentheses are for serial communications and LogicPro.
Default: *continuous* (0)
Modbus Address (Loops 1 to 9): 44205 to 44213 (heat) or 44222 to 44230 (cool)
Parameter Number: 72 (heat) or 73 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 72.1 to 72.9 (heat) or 73.1 to 73.9 (cool)

Sensor Fail Heat/Cool Output



A loop will switch to manual mode at the specified output power if one of the following conditions occurs while in automatic mode:

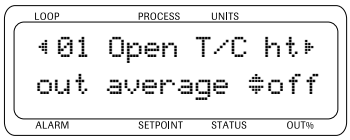
- A failed sensor alarm occurs, or
- The mode override input becomes active (see *Mode Override on page 99*).

For most applications, this parameter should be set to 0% for both heat and cool outputs.

Values: 0 to 100% (0 to 1000). Values in parentheses are for serial communications and LogicPro.
Default: 0% (0)
Modbus Address (Loops 1 to 9): 44239 to 44247 (heat) or 44256 to 44264 (cool)
Parameter Number: 74 (heat) or 75 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 74.1 to 74.9 (heat) or 75.1 to 75.9 (cool)
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Percentage Values on page 80*.

WARNING! ***Do not rely solely on the failed sensor alarm to adjust the output in the event of a sensor failure. If the loop is in manual mode when a failed sensor alarm occurs, the output is not adjusted. Install independent external safety devices to shut down the system if a failure occurs.***

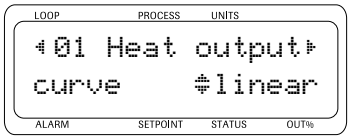
Open Thermocouple Heat/Cool Output Average



If you set this parameter to *on* and a thermocouple open alarm occurs, a loop set to automatic control mode will switch to manual mode at the average output prior to the alarm.

Values: *on* (1) or *off* (0). Values in parentheses are for serial communications and LogicPro, and are stored as the second (heat) or third bit (cool) of the value at this address.
Default: *off* (0)
Modbus Address (Loops 1 to 9): 44443 to 44451, second bit (heat) or third bit (cool)
Parameter Number: 86
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 86.1 to 86.9, second bit (heat) or third bit (cool)

Heat/Cool Output Curve



Choose an output curve. If curve 1 or 2 is selected, a PID calculation results in a lower actual output level than the linear output requires. Use curve 1 or 2 if the system has a nonlinear response to the output device.

Values: *linear* (0), curve *1* (1) or curve *2* (2). Values in parentheses are for serial communications and LogicPro.
Default: *linear* (0)
Modbus Address (Loops 1 to 9): 44273 to 44281 (heat) or 44290 to 44298 (cool)
Parameter Number: 76 (heat) or 77 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 76.1 to 76.9 (heat) or 77.1 to 77.9 (cool)

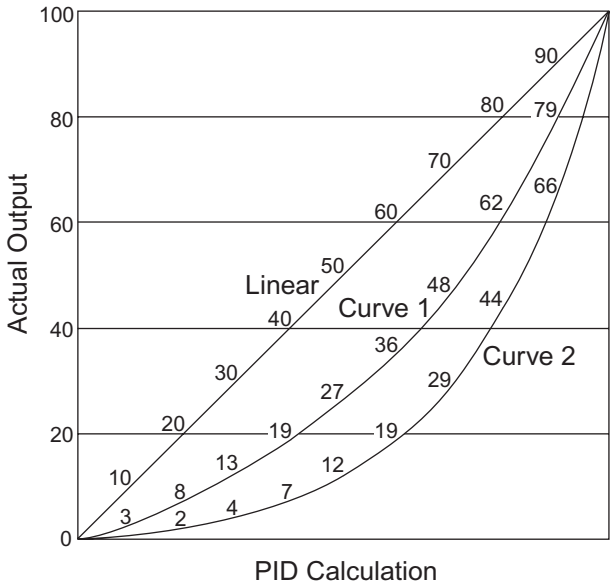
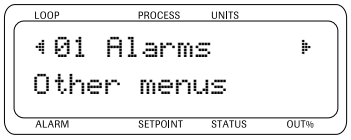


Figure 5.4 Linear and Nonlinear Outputs

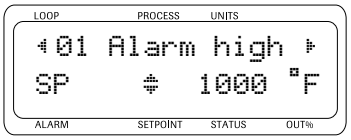
Alarms Menu



Use the *Alarms* menu to configure high alarms, low alarms, and deviation alarms, including:

- Alarm set points
- Alarm outputs
- Alarm behavior
- Alarm hysteresis
- Alarm delay

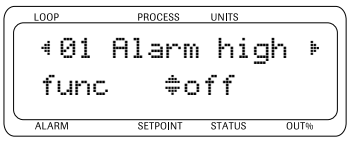
Alarm High Set Point



Enter the set point at which the high alarm activates. The high alarm activates if the process variable rises above this value. For more information about the high alarm, see *Alarm High and Alarm Low on page 66*.

Values: For a thermocouple or RTD input, any value within the input range (see *Table 5.7 on page 104*). For a process or pulse input, any value between the *Input range low* and *Input range high* parameters.
Default: 1000. Decimal placement depends upon the *Input type* and *Disp format* settings.
Modbus Address (Loops 1 to 9): 40307 to 40315
Parameter Number: 18
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 18.1 to 18.9
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

Alarm High Function



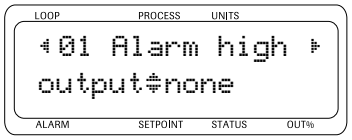
Choose whether the high alarm functions as an alarm or as a boost output, or disable the alarm.

Values: See *Table 5.16*.
Default: *off*
Modbus and LogicPro: See *Alarm Acknowledge on page 132* and *Alarm Function on page 133*.

Table 5.16 Alarm Functions

Value	Description
off	No alarm function.
standard	Alarm is indicated and logged. Latching global alarm is activated. Alarm must be acknowledged to clear. Optional non-latching alarm output is activated.
boost	Alarm message on controller display only. Alarm does not require acknowledgement. Non-latching alarm output is activated. Use the alarm set points to control this output for boost control.

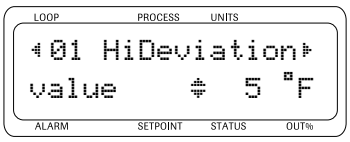
Alarm High Output



Choose a digital output to activate when the high alarm occurs. You cannot choose an output that is in use for closed-loop control or for the Serial DAC clock.

Values: *none* (0) or output 1 to 34 (1 to 34). Values in parentheses are for serial communications and LogicPro.
Default: *none* (0)
Modbus Address (Loops 1 to 9): 40426 to 40434
Parameter Number: 25
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 25.1 to 25.9

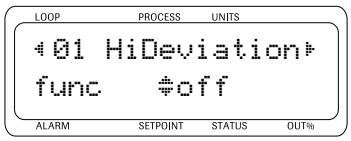
High Deviation Value



Enter the amount by which the process variable must rise above the set point for the high deviation alarm to occur. For more information, see *Deviation Alarms on page 66*.

Values: See *Table 5.13 on page 113* for values and decimal placement.
Default: See *Table 5.13 on page 113*.
Modbus Address (Loops 1 to 9): 40341 to 40349
Parameter Number: 20
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 20.1 to 20.9

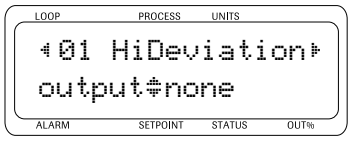
High Deviation Function



Choose whether the alarm functions as an alarm or as a boost output, or disable the alarm.

Values: See *Table 5.16 on page 122*.
Default: *off*
Modbus and LogicPro: See *Alarm Acknowledge on page 132* and *Alarm Function on page 133*.

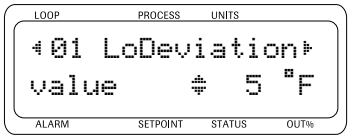
High Deviation Output



Choose a digital output to activate when the high deviation alarm occurs. You cannot choose an output that is in use for closed-loop control or for the Serial DAC clock.

Values: *none* (0) or output 1 to 34 (1 to 34). Values in parentheses are for serial communications and LogicPro.
Default: *none* (0)
Modbus Address (Loops 1 to 9): 40460 to 40468
Parameter Number: 27
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 27.1 to 27.9

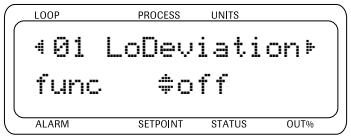
Low Deviation Value



Enter the amount by which the process variable must fall below the set point for the low deviation alarm to occur. For more information, see *Process Alarms on page 65*.

Values: See *Table 5.13 on page 113* for values and decimal placement.
Default: *Table 5.13 on page 113*
Modbus Address (Loops 1 to 9): 40358 to 40366
Parameter Number: 21
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 21.1 to 21.9

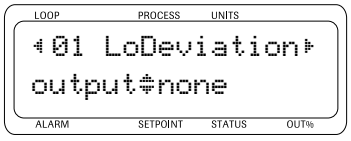
Low Deviation Function



Choose whether the alarm functions as an alarm or as a boost output, or disable the alarm.

Values: See *Table 5.16 on page 122*.
Default: *off*
Modbus and LogicPro: See *Alarm Acknowledge on page 132* and *Alarm Function on page 133*.

Low Deviation Output

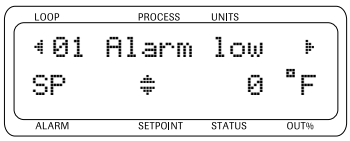


Choose a digital output to activate when the low deviation alarm occurs. You cannot choose an output that is in use for closed-loop control or for the Serial DAC clock.

Values: *none* (0) or output 1 to 34 (1 to 34). Values in parentheses are for serial communications and LogicPro.

Default: *none* (0)
Modbus Address (Loops 1 to 9): 40477 to 40485
Parameter Number: 28
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 28.1 to 28.9

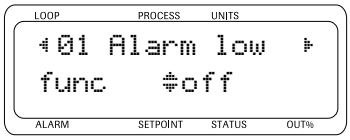
Alarm Low Set Point



Enter the set point at which the low alarm activates. The low alarm activates if the process variable drops below this value. For more information, see *Process Alarms on page 65*.

Values: For a thermocouple or RTD input, any value within the input range (see *Table 5.7 on page 104*). For a process or pulse input, any value between the *Input range low* and *Input range high* parameters.
Default: 0
Modbus Address (Loops 1 to 9): 40324 to 40332
Parameter Number: 19
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 19.1 to 19.9
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

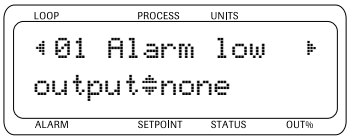
Alarm Low Function



Choose whether the alarm functions as an alarm or as a boost output, or disable the alarm.

Values: See *Table 5.16 on page 122*.
Default: *off*
Modbus and LogicPro: See *Alarm Acknowledge on page 132* and *Alarm Function on page 133*.

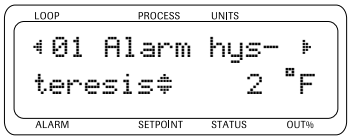
Alarm Low Output



Choose a digital output to activate when the low alarm occurs. You cannot choose an output that is in use for closed-loop control or for the Serial DAC clock.

Values: *none* (0) or output 1 to 34 (1 to 34). Values in parentheses are for serial communications and LogicPro.
Default: *none* (0)
Modbus Address (Loops 1 to 9): 40443 to 40451
Parameter Number: 26
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 26.1 to 26.9

Alarm Hysteresis



Enter the amount by which the process variable must return within the alarm limit before a high alarm, low alarm or deviation alarm clears. Use the alarm hysteresis to pre-

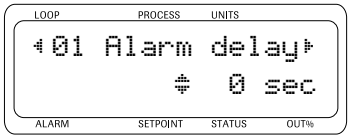
vent repeated alarms as the process variable cycles around an alarm limit.

Values: See *Table 5.17* for values and decimal placement.
Default: See *Table 5.17*.
Modbus Address (Loops 1 to 9): 40375 to 40383
Parameter Number: 22
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 22.1 to 22.9

Table 5.17 Values for Alarm Hysteresis

Input Type	Display Format	Values	Default
Thermocouple	n/a	0 to 500	2
RTD	n/a	0 to 500.0	2.0
Process or Pulse	-999 to 3000	0 to 500	2
	-9999 to 30000	0 to 5000	20
	-999.9 to 3000.0	0.0 to 500.0	2.0
	-99.99 to 300.00	0.00 to 50.00	0.20
	-9.999 to 30.000	0.000 to 5.000	0.020
	-0.9999 to 3.0000	0.0000 to 0.5000	0.0020

Alarm Delay

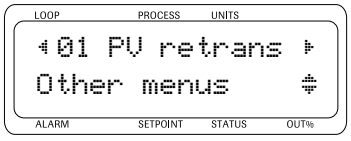


Use this parameter to delay a failed sensor or process alarm until the alarm condition has been continuously present for longer than the delay time.

To delay alarms on powerup only, see *Power Up Alarm Delay on page 100*.

Values: 0 to 255 seconds.
Default: 0
Modbus Address (Loops 1 to 9): 40562 to 40570
Parameter Number: 33
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 33.1 to 33.9

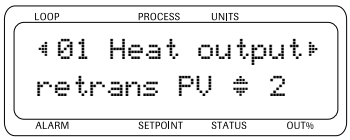
Process Variable Retransmit Menu



Use the *PV retrans* menu to configure an output so that it will retransmit the process variable from another loop. For details, see *Setting Up Process Variable Retransmit on page 67*.

This menu contains parameters for both heat and cool outputs. The sample screens in this section show the heat parameters, but the descriptions apply to both the heat and cool parameters.

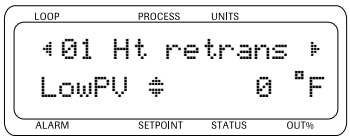
Heat/Cool Output Retransmit



Choose the loop that provides the process variable to be retransmitted. For example, in the sample display at left, the heat output from loop 1 (01) will retransmit the process variable from loop 2.

Values: *none* (0), or loop 1 to 5 (1 to 5) for a CPC404 or 1 to 9 (1 to 9) for a CPC408. Values in parentheses are for serial communications and LogicPro.
Default: *none* (0)
Modbus Address (Loops 1 to 9): 44478 to 44486 (heat) or 44495 to 44503 (cool)
Parameter Number: 89 (heat) or 90 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 89.1 to 89.9 (heat) or 90.1 to 90.9 (cool)

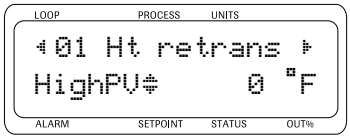
Heat/Cool Retransmit Low Process Variable



Enter the value of the process variable to retransmit as a 0 percent output signal. If the process variable falls below this value, the output will stay at 0 percent.

Values: Any value within the input sensor range; see *Table 5.7 on page 104*.
Default: The minimum value in the input sensor range
Modbus Address (Loops 1 to 9): 44546 to 44554 (heat) or 44563 to 44571 (cool)
Parameter Number: 93 (heat) or 94 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 93.1 to 93.9 (heat) or 94.1 to 94.9 (cool)
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

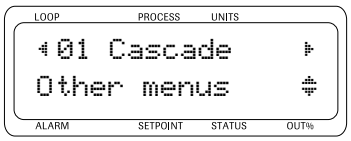
Heat/Cool Retransmit High Process Variable



Enter the value of the process variable to retransmit as a 100 percent output signal. If the process variable rises above this value, the output will stay at 100 percent.

Values: Any value within the input sensor range; see *Table 5.7 on page 104*.
Default: The maximum value in the input sensor range
Modbus Address (Loops 1 to 9): 44512 to 44520 (heat) or 44529 to 44537 (cool)
Parameter Number: 91 (heat) or 92 (cool)
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 91.1 to 91.9 (heat) or 92.1 to 92.9 (cool)
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

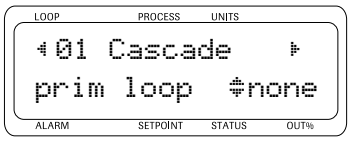
Cascade Menu



Use the cascade menu to configure cascade control. Use cascade control to calculate the set point of the current loop (the secondary, or outer, loop) based upon the output of another loop (the primary, or inner, loop).

For more information about cascade control, see *Setting Up Cascade Control on page 69*.

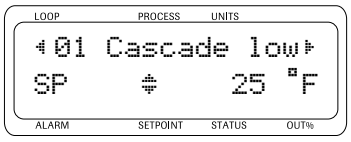
Cascade Primary Loop



Choose the primary loop. The controller uses the output of the primary loop to calculate the set point of the current loop.

Values: *none* (0), or loop 1 to 5 (1 to 5) for a CPC404 or 1 to 9 (1 to 9) for a CPC408. You cannot choose the current loop. Values in parentheses are for serial communications or LogicPro.
Default: *none* (0)
Modbus Address (Loops 1 to 9): 44648 to 44654
Parameter Number: 99
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 99.1 to 99.9

Cascade Low Set Point

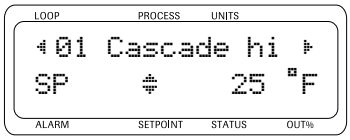


Enter the set point to use for the current loop when the output of the primary loop is at its minimum value. The set point will never drop below this value.

- If the primary loop has only the heat output enabled, then this value is the set point when the heat output of the primary loop is 0 percent.
- If the primary loop has only the cool output enabled or has the heat and cool outputs enabled, then this value is the set point when the cool output is 100 percent.

Values: For a thermocouple or RTD input, any value within the input range (see *Table 5.7 on page 104*). For a process or pulse input, any value between the *Input range low* and *Input range high* parameters. This value must be less than the *Cascade hi SP* parameter.
Default: 25 for a thermocouple, RTD or process input; 0 for the pulse input
Modbus Address (Loops 1 to 9): 44682 to 44690
Parameter Number: 101
LogicPro Driver: Database.
LogicPro Address (Loops 1 to 9): 101.1 to 101.9
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

Cascade High Set Point

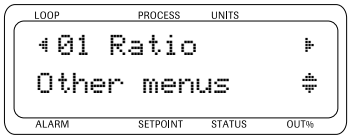


Enter the set point to use for the current loop when the output of primary loop is at its maximum value. The set point will never exceed this value.

- If the primary loop has only the heat output enabled, or has the heat and cool outputs enabled, this value is the set point when the output of the primary loop is 100 percent.
- If the primary loop has only the cool output enabled, then this value is the set point when the output of the primary loop is 0 percent.

Values: For a thermocouple or RTD input, any value within the input range (see *Table 5.7 on page 104*). For a process or pulse input, any value between the *Input range low* and *Input range high* parameters. This value must be greater than the *Cascade low SP* parameter.
Default: 25 for a thermocouple, RTD or process input; 0 for the pulse input
Modbus Address (Loops 1 to 9): 44699 to 44707
Parameter Number: 102
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 102.1 to 102.9
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

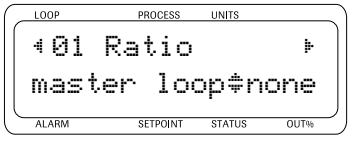
Ratio Menu



Use the ratio menu to configure ratio control, differential control or remote analog set point. Use these control methods to calculate the set point of the current loop (the ratio loop) based upon the process variable of another loop (the master loop).

For more information about ratio control, see *Setting Up Ratio Control on page 73*, *Setting Up Differential Control on page 75* and *Setting Up Remote Analog Set Point on page 76*.

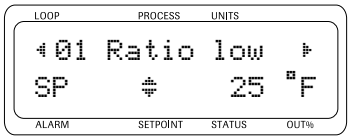
Ratio Master Loop



Choose the master loop. The controller uses the process variable of the master loop to calculate the set point of the current loop.

Values: *none* (0), or loop 1 to 5 (1 to 5) for a CPC404 or 1 to 9 (1 to 9) for a CPC408. You cannot choose the current loop.
Default: *none* (0)
Modbus Address (Loops 1 to 9): 44750 to 44758
Parameter Number: 105
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 105.1 to 105.9

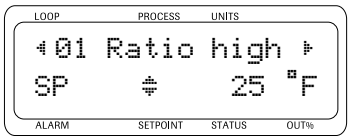
Ratio Low Set Point



Enter the lowest allowable set point for the current loop. The set point will never drop below this value, regardless of the result of the ratio calculation.

Values: For a thermocouple or RTD input, any value within the input range (see *Table 5.7 on page 104*). For a process or pulse input, any value between the *Input range low* and *Input range high* parameters. This value must be less than the *Ratio high SP* parameter.
Default: 25 (or 0 for the pulse input)
Modbus Address (Loops 1 to 9): 44767 to 44775
Parameter Number: 106
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 106.1 to 106.9
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

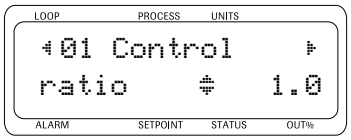
Ratio High Set Point



Enter the highest allowable set point for the current loop. The set point will never exceed this value, regardless of the result of the ratio calculation.

Values: For a thermocouple or RTD input, any value in the input sensor range; see *Table 5.7 on page 104*. For a process or pulse input, any value from *Input range low* to *Input range high*. This value must be greater than the *Ratio low SP* parameter.
Default: 25 (0 for the pulse input)
Modbus Address (Loops 1 to 9): 44784 to 44792
Parameter Number: 107
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 107.1 to 107.9
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

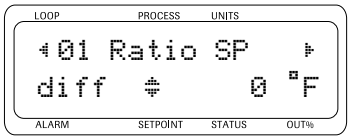
Control Ratio



Enter the factor by which to multiply the process variable of the master loop to calculate the set point of the ratio loop.

Values: .1 to 999.9 (1 to 9999). Values in parentheses are for serial communications and LogicPro (values are in tenths).
Default: 1.0 (10) for a thermocouple, RTD or process input; .0 (0) for a pulse input
Modbus Address (Loops 1 to 9): 44801 to 44809
Parameter Number: 108
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 108.1 to 108.9

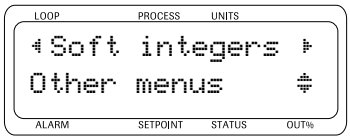
Ratio Set Point Differential



Enter the value to add to the ratio calculation before using it as the set point.

Values: -9999 to 9999. Decimal placement depends upon the *Input type* and *Disp format* values in the *Input* menu.
Default: 0
Modbus Address (Loops 1 to 9): 44818 to 44826
Parameter Number: 109
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 109.1 to 109.9
Decimal Placement for Modbus or LogicPro: See *Decimal Placement for Numeric Values on page 80*.

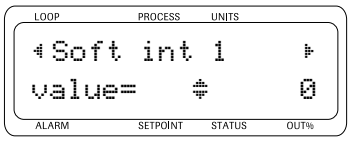
Soft Integers Menu



The *Soft integers* menu contains 1,100 user-definable, 16-bit word registers. Use these parameters to read and set integer data.

Read and write access are available through a logic program, WatView HMI software, the controller display or a third-party host.

Soft Integer Value

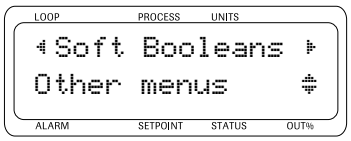


Read or set an integer value. For example, suppose that you use serial communications to retrieve the input temperature from four different inputs, and you have a program that calculates the average input temperature. You could write the average input temperature to one of the *Soft int* parameters so that the operator could read it.

Values: -32768 to 32767
Default: 0
Modbus Address (Soft Integers 1 to 100): 44883 to 44982
Modbus Address (Soft Integers 101 to 1100): 45496 to 46496
Parameter Number (Soft Integers 1 to 100): 126
Parameter Number (Soft Integers 101 to 1100): 140
LogicPro Driver: Soft_Int
LogicPro Address: 1 to 1100

NOTE! ***The values of soft integers 81 to 100 are saved in jobs, and the values of soft integers 1 to 80 and 101 to 1100 are not.***

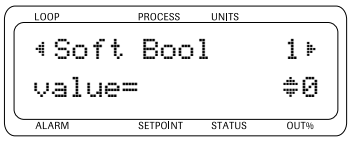
Soft Booleans Menu



The *Soft Booleans* menu contains 256 one-bit Boolean registers. Use these parameters to read and set Boolean (true or false) data.

Read and write access are available through a logic program, WatView, the controller display or a third-party host.

Soft Boolean Value

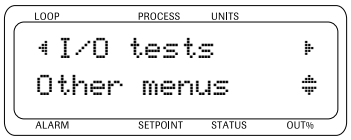


Read or set a true or false value.

Values: 0 (false) or 1 (true)
Default: 0
Modbus Address (Soft Boolean 1 to 256): 44983 to 45238
Parameter Number: 127
LogicPro Driver: Soft_Bool
LogicPro Address (Soft Boolean 1 to 256): 1 to 256

NOTE! ***The values of soft Booleans 237 to 256 are saved in jobs, the values of soft Booleans 1 to 236 are not.***

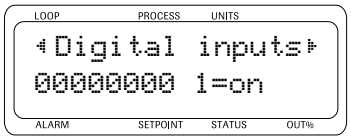
I/O Tests Menu



Use the *I/O tests* menu to test the following:

- Digital inputs
- Digital outputs
- Keypad

Digital Inputs



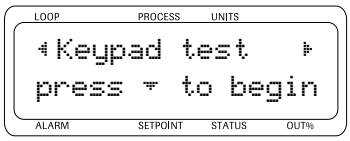
This parameter indicates the states of the eight digital inputs. A *1* indicates that the input is connected to controller common (on). A *0* indicates an open circuit (off).

To test an input, short it to controller common. When the input is shorted, its input state should be *1*. For detailed instructions, see *Digital Input Test on page 27*.

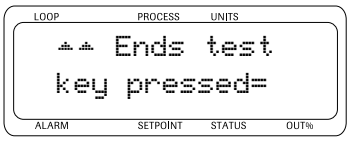
The controller display shows the states of digital inputs 1 to 8 from left to right. For serial communications and LogicPro programs, read the state of one input at a time.

Values: 0 if the input is off, 1 if the input is on
Modbus Address (Digital Inputs 1 to 8): 40719 to 40726
Parameter Number: 46
LogicPro Driver: CPC400_Digital_In
LogicPro Address (Digital Inputs 1 to 8): 1 to 8

Keypad Test



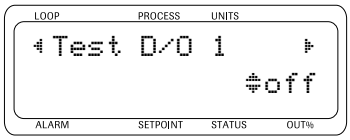
To test the keypad, press ▼. This screen will appear:



To test a key, press it. If the key is working properly, an icon for that key appears.

When you are done testing the keypad, press ▲▲ to return to the *Keypad test* parameter.

Test Digital Output 1 to 35



Use the *Test D/O* parameter to manually toggle a digital output on and off. Choose *on* to sink the current from the output to the controller common. Choose *off* to stop the current flow. For instructions, see *Digital Output Test on page 26*. You cannot toggle an output that is enabled for control.

NOTE! ***When you exit the* I/O tests *menu, all outputs that were forced on are turned off.***

Values: *off* (0) or *on* (1)
Default: *off* (0)
Modbus Address (Digital Outputs 1 to 35): 40751 to 40785
Parameter Number: 47
LogicPro Driver: CPC400_Digital_Out
LogicPro Address (Digital Outputs 1 to 35): 1 to 35

Additional Parameters for Serial Communications and LogicPro Programs

These parameters are available only for serial communications and LogicPro programs. They are not accessible through the controller keypad.

Alarm Acknowledge

Indicates whether an alarm has been acknowledged. To acknowledge an alarm, clear the bit for that alarm. *Table 5.19* shows which bit corresponds to each alarm. See *Bit-Wise Values on page 78* for information on reading or setting this parameter.

This parameter is available only for serial communications and LogicPro programs.

Values: Unacknowledged (1) or acknowledged (0)
Modbus Address (Loops 1 to 9): 40511 to 40519
Parameter Number: 30
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 30.1 to 30.9

Alarm Enable

Enable or disable an alarm. *Table 5.18* shows the bit to set or read for each alarm. This parameter is available only for serial communications and LogicPro programs. See *Bit-Wise Values on page 78* for information on reading or setting this parameter.

Values: Disabled (0) or enabled (1)
Default: Disabled (0)
Modbus Address (Loops 1 to 9): 40528 to 40536
Parameter Number: 31
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 31.1 to 31.9

Table 5.18 Bit Positions for Alarm Enable and Alarm Function

Alarm	Bit
Low Deviation Alarm	Third
High Deviation Alarm	Fourth
Alarm Low	Fifth
Alarm High	Sixth

Alarm Function

Choose whether an alarm behaves as a standard alarm or as a boost output. For descriptions of the standard and boost functions, see *Table 5.16 on page 122*. *Table 5.18* shows the bit to set or read for each alarm. See *Bit-Wise Values on page 78* for information on reading or setting this parameter.

This parameter is available only for serial communications and LogicPro programs.

Values: Standard alarm (0) or boost output (1)
Default: Standard alarm (0)
Modbus Address (Loops 1 to 9): 40494 to 40502
Parameter Number: 29
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 29.1 to 29.9

Alarm Status

Indicates whether an alarm is active. *Table 5.19* shows the bit to set or read for each alarm. This parameter is available only for serial communications and LogicPro programs. See *Bit-Wise Values on page 78* for information on reading or setting this parameter.

Values: Not active (0) or active (1)
Modbus Address (Loops 1 to 9): 40392 to 40400
Parameter Number: 23
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 23.1 to 23.9

Table 5.19 Bit Positions for Alarm Status and Alarm Acknowledge

Alarm	Bit
Low Deviation Alarm	Third
High Deviation Alarm	Fourth
Alarm Low	Fifth
Alarm High	Sixth
Thermocouple Reversed	Seventh
Thermocouple Shorted	Eighth
Thermocouple Open	Ninth
RTD Open	Tenth
RTD Shorted	Eleventh

Ambient Sensor Reading

This read-only parameter indicates the temperature measured by the cold-junction compensation sensor located near the analog input terminal block.

This parameter is available only for serial communications and LogicPro programs.

Values: Temperature in tenths of a degree Fahrenheit. To convert to Celsius, use the formula °C = 5/9(°F - 32).
Modbus Address: 40579
Parameter Number: 34
LogicPro Driver: Database
LogicPro Address: 34.1

Analog Input

Indicates the value measured by the sensor after filtering and scaling. This parameter is read-only.

Values: For thermocouples and RTD inputs, same as the input range (see *Table 5.7 on page 104*). For process, soft integer, and pulse inputs, any value between the Input Range Low and Input Range High parameters in the Input menu.
Modbus Address (Loops 1 to 9): 45375 to 45383
Parameter Number: 135
LogicPro Driver: Database
LogicPro Address (Loops 1 to 9): 135.1 to 135.9
Decimal Placement for Modbus or LogicPro: see *Decimal Placement for Numeric Values on page 80*.

Data Changed Register

This register is a tool for hosts which need to maintain a mirror image of the CPC400 database. Using a first in, first out stack, the change queue logs all changes to the database that do not originate with the host.

The data changed register contains the parameter number of the oldest change in the change queue. After the host reads the register, the second oldest parameter number is loaded, and so on. When there are no remaining changes to be read, the register contains FF (hexadecimal).

This parameter is available only for serial communications and LogicPro programs.

Values: -1 to 255
Modbus Address: 40791
Parameter Number: 50
LogicPro Driver: Database
LogicPro Address: 50.1

Firmware Identification

Indicates whether the flash memory chip contains standard or custom Watlow Anafaze firmware for the closed-loop control program. (If a logic program is loaded onto the flash memory chip, it has *no* effect on this parameter.)

This parameter is available only for serial communications and LogicPro programs.

Values: 0 indicates standard firmware, any other value indicates custom firmware.
Modbus Address: 40847
Parameter Number: 52
LogicPro Driver: Database
LogicPro Address: 52.1

Firmware Version

For serial communications and LogicPro programs, you can retrieve the firmware version in three parts: major part, minor part and revision letter.

Major Part

Indicates the firmware version number to the left of the decimal point, such as "1" for version 1.07A.

Modbus Address: 40844
Parameter Number: 52
LogicPro Driver: Database
LogicPro Address: 52.2

Minor Part

Indicates the firmware version number in the hundredths place to the right of the decimal point, such as "7" for version 1.07A.

Modbus Address: 40845
Parameter Number: 52
LogicPro Driver: Database
LogicPro Address: 52.3

Revision Letter

Indicates the ASCII code value for the firmware version letter, if present, such as "65" (the ASCII value for "A") for version 1.07A.

Modbus Address: 40846
Parameter Number: 52
LogicPro Driver: Database
LogicPro Address: 52.4

Full Scale Calibration

This read-only parameter indicates the signal level detected when the controller measures its full scale reference voltage in performing its self-calibration. If the value drifts out of specified limits, the controller places all loops in manual mode at 0 percent power and indicates a hardware failure.

This parameter is available only for serial communications and LogicPro programs.

Values: 0 to 32767 counts
Modbus Address: 40718
Parameter Number: 45
LogicPro Driver: Database
LogicPro Address: 45.1

System Status

Check the status of the specific system conditions listed in *Table 5.20*. This parameter is available only for serial communications and LogicPro programs. See *Bit-Wise Values on page 78* for information on reading this parameter.

Values: See *Table 5.20*.
Modbus Address: 40786 (first to eighth bit), 40787 (ninth to sixteenth bit)
Parameter Number: 48
LogicPro Driver: Database
LogicPro Address: 48.1 (first to eighth bit), 48.2 (ninth to sixteenth bit)

Table 5.20 System Status Bits

Parameter	Description	Values	Bit
Battery Status	Indicates whether the values in RAM have been corrupted while the power has been off.	0: No corruption detected 1: Data corrupted	First
Ambient Status	Indicates whether the ambient temperature is within the controller's operating range. If the ambient is out of range, the controller sets all loops to manual mode at 0 percent power.	0: Within range 1: Outside of range	Fourth
Zero Status	Indicates whether the zero self-calibration measurement falls within acceptable limits.	0: In calibration 1: Out of calibration	Sixth
Full Scale Status	Indicates whether the full scale self-calibration measurement falls within acceptable limits.	0: In calibration 1: Out of calibration	Seventh
Power Up Alarm Delay Status	Indicates whether the power-up alarm delay feature is presently active. See *Power Up Alarm Delay on page 100*.	0: Delay feature not active 1: Delay feature active	Ninth

Zero Calibration

This read-only parameter indicates the signal level detected when the controller measures its zero reference voltage in performing its self-calibration. If the value drifts out of specified limits, the controller places all loops in manual mode at 0 percent power and indicates a hardware failure. This parameter is available only for serial communications and LogicPro.

Values: 0 to 32767 counts
Modbus Address: 40717
Parameter Number: 44
LogicPro Driver: Database
LogicPro Address: 44.1

6

Troubleshooting and Reconfiguring

This chapter explains how to troubleshoot and reconfigure the controller.

When There is a Problem

The controller is only one part of your control system. Often, what appears to be a problem with the controller is really a problem with other equipment, so check these things first:

- The controller is installed correctly. (See the Installation chapter.)
- Sensors, such as thermocouples and RTDs, are installed correctly and working.

NOTE! ***If you suspect your controller has been damaged, do not attempt to repair it yourself, or you may void the warranty.***

If the troubleshooting procedures in this chapter do not solve your system's problems, call the Technical Services department for additional troubleshooting help. If you need to return the unit to Watlow Anafaze for testing and repair, Customer Services will issue you an RMA number. See *Returning a Unit on page 140*.

CAUTION! ***Before trying to troubleshoot a problem by replacing your controller with another one, first check the installation. If you have shorted sensor inputs to high voltage lines or a transformer is shorted out, and you replace the controller, you will risk damage to the new controller.***

If you are certain the installation is correct, you can try replacing the controller. If the second unit works correctly, then the problem is specific to the controller you replaced.

Returning a Unit

Before returning a controller, contact your supplier or call Watlow Anafaze at (831) 724-3800 for technical support.

Controllers purchased as part of a piece of equipment must be serviced or returned through the equipment manufacturer. Equipment manufacturers and authorized distributors should call customer service at Watlow Anafaze to obtain a return materials authorization (RMA) number. Shipments without an RMA will not be accepted. Other users should contact their suppliers for instructions on returning products for repair.

Troubleshooting the Controller

A problem may be indicated by one or more of several types of symptoms:

- A process alarm
- A failed sensor alarm
- A system alarm
- Unexpected or undesired behavior

The following sections list symptoms in each of these categories and suggest possible causes and corrective actions.

Process Alarms

When a process alarm occurs, the controller switches to the single-loop display for the loop with the alarm and displays the alarm code (see *Alarm Displays on page 51*). WatView software displays a message on the alarm screen and logs the alarm in the event log.

Possible Causes of a Process Alarm

In a heating application, a low alarm or low deviation alarm may indicate one of the following:

- The heater has not had time to raise the temperature.
- The load has increased and the temperature has fallen.
- The control mode is set to manual instead of automatic.
- The heaters are not working because of a hardware failure.
- The sensor is not placed correctly and is not measuring the load's temperature.
- The alarm settings are too tight. The process variable varies by more than the alarm limits because of load changes, lag or other system conditions.
- The system is so poorly tuned that the temperature is cycling about set point by more than the alarm set point.

NOTE! ***In cooling applications, similar issues cause high alarms.***

In a heating application, a high alarm or high deviation alarm may indicate one of the following:

- The process set point and high alarm set point have been lowered and the system has not had time to cool to within the new alarm setting.
- The controller is in manual mode and the heat output is greater than 0 percent.
- The load has decreased such that the temperature has risen.
- The heater is full-on because of a hardware failure.
- The system is so poorly tuned that the temperature is cycling about set point by more than the alarm set point.

NOTE! ***In cooling applications, similar issues cause low alarms.***

Responding to a Process Alarm

Your response to an alarm depends upon the alarm function setting, as explained in *Table 6.1*.

Table 6.1 Operator Response to Process Alarms

Alarm Function	Operator Response
Boost	The operator does not need to acknowledge the alarm. The alarm clears automatically when the process variable returns within limits.
Standard	Acknowledge the alarm by pressing on the keypad or by using HMI software. The alarm clears after the operator acknowledges it *and* the process variable returns within the limits.

Failed Sensor Alarms

When a failed sensor alarm occurs, the controller switches to the single loop display for the loop with the alarm and displays an alarm code (see *Alarm Displays on page 51*). WatView software displays a message on the alarm screen and logs the alarm in the event log.

A failed sensor alarm clears once it has been acknowledged and the sensor is repaired. For more information about the causes of failed sensor alarms, see *Failed Sensor Alarms on page 63*.

Disable Failed Sensor Functions

When a loop uses the Soft Integer for a PV Source, some failed sensor functions are disabled. These include functions that require linkages between specific thermocouple or RTD input and loop outputs to operate correctly. When a loop uses a soft integer as the PV Source, the thermocouple or RTD no longer has a direct relationship to a specific loop output.The failed sensor functions disabled are:

- *Thermocouple Short Alarm* (Global)
- *Reversed Thermocouple Detection* (Loop)
- *Restore Automatic Mode* (Loop)
- *Sensor Fail Heat/Cool Output* (Loop)
  This parameter will switch a loop to manual mode at the specified output power if a failed sensor alarm occurs or the mode override input becomes active. Only the function that sets the output based on a failed sensor is disabled.
- *Open Thermocouple Heat/Cool Output Average* (Loop)

System Alarms

If the controller detects a hardware problem, it displays an alarm message. The message persists until the condition is corrected.

The CPC400 displays the following system alarm messages:

- *Low power*: See *Low Power on page 145*.
- *Battery dead*: See *Battery Dead on page 145*.
- *H/W failure: Ambient*: See *H/W Failure: Ambient on page 146*.
- *H/W failure: Gain*: See *H/W Failure: Gain or Offset on page 146*.
- *H/W failure: Offset*: See *H/W Failure: Gain or Offset on page 146*.

Other Behaviors

Table 6.2 indicates potential problems with the system or controller and recommends corrective actions.

Table 6.2 Other Symptoms

Symptom	Possible Causes	Recommended Action
Indicated temperature not as expected	Controller not communicating Sensor wiring incorrect Noise	See *Checking Analog Inputs on page 148*.
CPC400 display is not lit	Power connection incorrect	Check wiring and service. See *Wiring the Power Supply on page 24*.
	Failed flash memory chip	Replace the flash memory chip. See *Replacing the Flash Memory Chip on page 154.*
	CPC400 damaged or failed	Return the CPC400 for repair. See *Returning a Unit on page 140*.
CPC400 display is lit, but keys do not work	Keypad locked	See *Keys Do Not Work on page 147*.
	Unacknowledged alarm	An alarm condition exists and has not been acknowledged. See *How to Acknowledge an Alarm on page 52*.
	CPC400 damaged or failed	Return the CPC400 for repair. See *Returning a Unit on page 140*.

Symptom	Possible Causes	Recommended Action
Control mode of one or more loops changes from automatic to manual	Failed sensor	Check the display or HMI software for a failed sensor message.
	BCD job selection feature loaded a different job	Check whether the new job was supposed to be loaded. If not, check the BCD job load setup: Check the settings of the BCD job load parameters in the *Global setup* menu. Use the *Digital inputs* parameter in the *I/O tests* menu to test the BCD job load input(s). Check the device that is used to activate job selection.
All loops are in manual mode at 0 percent power	Intermittent power	Check wiring and service. See *Wiring the Power Supply on page 24*. Use a separate dc supply for the controller. Provide backup power (uninterruptible power system). In the *Global* menu, set the *Power up loop mode* parameter to *from memory* if safe for your application. See *Power Up Loop Mode on page 100*.
	Analog reference voltage overloaded	Disconnect any wiring from the +5V Ref connection on TB1.
	Hardware failure	Check the controller display for a hardware alarm. See *System Alarms on page 143*.
Logic does not run	No logic program loaded	Load a logic program. For more information, see the *LogicPro User's Guide*.
	Controller not set to run logic on powerup	Run the logic program; see *Logic Program on page 99*. If desired, set the controller to start the logic program automatically upon powerup; see *Power Up With Logic on page 100*.
Controller does not behave as expected	Corrupt or incorrect values in RAM	Clear the RAM. See *Clearing the RAM on page 153*.

Corrective and Diagnostic Procedures

The following sections detail procedures you may use to diagnose and correct problems with the controller.

Low Power

If the controller displays *Low power* or the display is not lit:

1. Turn the power to the controller off, then on again.
2. If the *Low power* alarm message returns, check that the power supplied to the controller is at least 12.0V⎓ (dc) at 1 A. See *Wiring the Power Supply on page 24*.
3. If the alarm message returns again, make a record of all controller settings. Then, clear the RAM. See *Clearing the RAM on page 153*.
4. If the alarm is not cleared, contact your supplier for further troubleshooting guidance. See *Returning a Unit on page 140*.

Battery Dead

The *Battery dead* alarm indicates that the battery in the CPC400 is not functioning correctly. This alarm occurs upon powerup only. The alarm indicates that values stored in memory may have been corrupted because of battery failure.

NOTE! ***The controller retains its settings when powered. The battery is required to keep the settings in memory only when the controller is powered down.***

If a replacement controller is available:

1. Make a record of all controller settings. Verify that the settings are correct, because memory failure may have changed some settings.
2. Replace the controller.
3. Enter the settings into the new controller.

If you must use the controller with the failed battery:

1. Make a record of all controller settings. Verify that the settings are correct, because memory failure may have changed some settings.
2. Clear the controller RAM; see *Clearing the RAM on page 153*. Clearing the RAM clears all settings, including internal settings that may have been corrupted.
3. Re-enter your settings.

Ambient Warning

The ambient warning alarm indicates that the ambient temperature of the controller is too hot or cold. Ambient warning occurs when the controller's temperature is in the range of 23 to 32°F or 122 to 131°F. The operating limits are 32 to 122°F.

If the controller displays AW in the lower left corner of the display:

1. Acknowledge the alarm.
2. If the error message remains, check the ambient air temperature near the controller. Adjust ventilation, cooling or heating to ensure that the temperature around the controller is 32 to 122°F. If the unit is functioning correctly, the error will clear automatically when the ambient temperature is within range and the alarm has been acknowledged.
3. If error persists, make a record of the settings, then clear the RAM. See *Clearing the RAM on page 153*.
4. If the error is not cleared, contact your supplier for futher troubleshooting guidelines. See *Returning a Unit on page 140*.

H/W Failure: Gain or Offset

If the controller displays *H/W failure: Gain* or *H/W failure: Offset*:

1. Acknowledge the alarm
2. If the error message remains, switch the power to the controller off, then on again.
3. If the alarm persists, make a record of all controller settings, then clear the RAM. See *Clearing the RAM on page 153.*
4. If the alarm is not cleared, contact your supplier for further troubleshooting guidelines. See *Returning a Unit on page 140.*

NOTE! ***If the controller has failed, it may have been damaged by excessive voltage. Before replacing the controller, troubleshoot for high ac voltage on sensors or outputs. See Checking Analog Inputs on page 148.***

H/W Failure: Ambient

The *H/W failure: Ambient* alarm indicates that the ambient sensor in the CPC400 is reporting that the temperature around the controller is outside of the acceptable range of 0

to 50°C. This alarm can also occur if there is a hardware failure.

If the controller displays *H/W failure: Ambient*:

1. Acknowledge the alarm.
2. If the error message remains, check the ambient air temperature near the controller. Adjust ventilation, cooling or heating so that the temperature around the controller is 0 to 50°C. If the unit is functioning correctly, the alarm will clear automatically when the ambient temperature is within range.
3. If the ambient temperature is within range and the alarm persists, reseat the board assembly:
   a) Switch off power to the controller.
   b) Remove the board assembly from the CPC400 housing.
   c) Reseat the board assembly and reassemble the controller.
   d) Switch on power to the controller.
4. If the alarm persists, make a record of all controller settings, then clear the RAM. See *Clearing the RAM on page 153*.
5. If the alarm is not cleared, contact your supplier for further troubleshooting guidelines. See *Returning a Unit on page 140*.

NOTE! ***If the controller has failed, it may have been damaged by excessive voltage. Before replacing the controller, troubleshoot for high ac voltage on sensors or outputs. See Checking Analog Inputs on page 148.***

Keys Do Not Work

If the CPC400 seems to function but one or more keys do not work, check the following:

- If the ⏵ key does not work, but other keys work, then the keypad is probably locked. Unlock the keypad according to the instructions in *Keypad Lock on page 101*.
- Check whether there is an unacknowledged alarm. The keys will not work for anything else until all alarms are acknowledged. To acknowledge an alarm, press ↩.

Checking Analog Inputs

Follow these steps to troubleshoot problems with the analog inputs to the CPC400 controller:

WARNING! ***Shorts between heaters and sensors or wiring errors can cause potentially lethal voltages to be present in the CPC400 and associated wiring and devices. Only qualified personnel taking appropriate precautions should attempt to troubleshoot or service equipment.***

1. If the process variable displayed in interface software does not agree with the process variable on the controller display, verify that the controller is communicating.
2. If the process variable indicated on the controller display is incorrect:
   a) Verify that you have selected the correct input type for the affected loops.
   b) Verify that sensors are properly connected.
3. If the sensors are correctly connected, with power on to the heaters check for high common mode voltage:
   a) Set a voltmeter to measure volts ac.
   b) Connect the negative lead to a good earth ground.
   c) Check each sensor input for ac voltage by connecting the one lead from the voltmeter to the sensor's positive input connection and the other lead from the voltmeter to the sensor's negative input connection.

   A voltage greater than 530V~ (ac) on one or more sensor connections indicates a heater leakage or a wiring problem. Correct this problem.
4. Check for voltage differences between sensors. A voltage difference between any two sensors in excess of 280V~ (ac) indicates a wiring problem or short.
   a) Connect the negative lead to the first sensor connection.
   b) With the positive lead measure the sensor-to-sensor potential at each of the other sensor connections.
   c) Move the negative lead to the next sensor.
   d) Repeat steps b and c to measure the voltage between each pair of sensors.
   e) Correct any problems indicated by excessive voltage readings.

5. Verify the sensors:
   - For thermocouples, remove the thermocouple leads and use a digital voltmeter to measure the resistance between the positive and negative thermocouple leads. A value of 2 to 20 Ω is normal. Readings in excess of 200 Ω indicate a problem with the sensor.
   - For RTDs, measure between the IN+ and IN- terminals of TB1. RTD inputs should read between 20 and 250 Ω.
6. To verify that the controller hardware is working correctly, check any input (except the pulse input or an RTD) as follows:
   a) Disconnect the sensor wiring.
   b) In the *Input* menu, set the *Input type* parameter to *J T/C*.
   c) Place a short across the input. On the loop that you are testing, the controller should indicate the ambient temperature.

Earth Grounding

If you suspect a problem with the ac ground or a ground loop:

- Measure for ac voltage between ac neutral and panel chassis ground. If ac voltage is above 2V~ (ac), then there may be a problem with the ac power wiring. This should be corrected per local electrical codes.
- With ac power on, measure for ac voltage that may be present between control panels' chassis grounds. Any ac voltage above 2V~ (ac) may indicate problems with the ac ground circuit.
- With the heater power on, check for ac voltage on thermocouples. A control output providing power to the heaters will increase the ac voltage if there is heater leakage and an improper grounding circuit. Measure from either positive or negative thermocouple lead to ac ground. AC voltage above 2V~ (ac) may indicate the ground lead is not connected to the CPC400 TB2 ground terminal.

If the above tests indicate proper ac grounding but the controller is indicating incorrect temperatures or process readings:

- Verify which type of sensor is installed and that the *Input type* parameter in the *Input* menu is set accordingly.

- For an RTD or process input, check that the correct input scaling resistors are installed (see *Installing Scaling Resistors on page 157*) and check the input scaling parameter settings (see *Setting Up a Process or Pulse Input on page 58*).
- If readings are erratic, look for sources of electrical noise. See *Noise Suppression on page 21*.
- Contact your supplier for further troubleshooting guidance.

Checking Control Outputs

To check control outputs:

- Set the loop you want to check to manual mode; see *Changing the Control Mode and Output Power on page 55*.
- Set the output power percentage to the desired level; see *Changing the Control Mode and Output Power on page 55*
- Set the output type to *on/off* or *TP*; see *Heat/Cool Output Type on page 116*.

If the control output is not connected to an output device like a solid-state relay, connect an LED in series with a 1 kΩ resistor from +5V to the output. (Connect the anode of the LED to +5V.) The LED should be off when the output is 0 percent and on when the output is 100 percent.

Testing Control Output Devices

Connect the solid-state relay control terminals to the CPC400 control output and connect a light bulb (or other load that can easily be verified) to the output terminals on the solid-state relay. Put the loop in manual mode and set the output to 100 percent. The ac load should turn on.

Do not attempt to measure ac voltage at the output terminals of the solid-state relay. Without a load connected, the solid-state relay output terminals do not turn off. This makes it difficult to determine whether the solid-state relay is actually working. Measure the voltage across a load or use a load that can be visually verified, such as a light bulb.

Testing the TB18 and TB50

1. Turn on power to the controller.
2. Measure the +5V⎓ (dc) supply at the TB18 or TB50. The voltage should be +4.75 to +5.25V⎓ (dc):
   a) Connect the voltmeter's common lead to TB18 terminal 2 or TB50 terminal 3.

b) Connect the voltmeter's positive lead to the TB18 or TB50 terminal 1.

Testing Control and Digital Outputs

1. Switch off power to the controller.
2. Disconnect any output wiring on the output to be tested.
3. Connect a 500 Ω to 100 kΩ resistor between the +5V terminal (TB18 or TB50 terminal 1) and the output terminal you want to test.
4. Connect the voltmeter's common lead to the output terminal, and connect the voltmeter's positive lead to the +5V terminal.
5. Restore power to the controller.
6. If you are testing a control output, turn the output on and off by setting the loop to 100 percent and 0 percent output power (see *Changing the Control Mode and Output Power on page 55*). When the output is off (0 percent), the output voltage should be less than 1V. When the output is on (100 percent), the output voltage should be between +3.75 and +5.25V.
7. If you are testing a digital output not used for control, use the *I/O tests* menu to turn the output on and off. See *Test Digital Output 1 to 35 on page 132*.

Testing Digital Inputs

1. Switch off power to the controller.
2. Disconnect any system wiring from the input to be tested.
3. Restore power to the controller.
4. Go to the *Digital inputs* parameter in the *I/O tests* menu.
5. Attach a wire to the terminal of the digital input to test. When the wire is connected only to the digital input terminal, the *Digital inputs* parameter should show that the input is off (*0*). When you connect the other end of the wire to controller common (TB50 terminal 3), the *Digital inputs* parameter should show that the input is on (*1*).

Additional Troubleshooting for Computer Supervised Systems

These four elements must work properly in a computer-supervised system:

- The controller
- The computer and its EIA/TIA-232 or EIA/TIA-485 serial interface
- The EIA/TIA-232 or EIA/TIA-485 communication lines
- The computer software

For troubleshooting, disconnect the communications line from the computer and follow the troubleshooting steps in the first section of this chapter. The next few sections explain troubleshooting for the other elements of computer supervised systems.

Computer Problems

If you are having computer or serial interface problems, check the following:

- Check your software manual and make sure your computer meets the software and system requirements.
- Check the communications interface, cables and connections. Make sure the serial interface is set according to the manufacturer's instructions.
- To test an EIA/TIA-232 interface, purchase an EIA/TIA-232 tester with LED indicators. Attach the tester between the controller and the computer. When the computer sends data to the controller, the TX LED on the tester should blink. When the computer receives data from the controller, the RX LED should blink.
- You can also connect an oscilloscope to the transmit or receive line to see whether data is being sent or received. If the serial port does not appear to be working, the software setup may need to be modified or the hardware may need to be repaired or replaced.

Communications

Most communications problems are due to incorrect wiring or incorrectly set communications parameters. Therefore, when there is a problem, check the wiring and communications settings first. Verify the following:

- **Communications Port:** Software must be configured to use the communications port to which the controller is connected.
- **Software Protocol:** The CPC400 supports the Modbus RTU protocol.

- **Controller Address:** Configure software to look for the controller at the correct address. In a multiple-controller installation, each controller must have a unique address.
- **Baud Rate:** Software and controller must be set the same.
- **Parity:** In the Modbus RTU protocol, the parity may be set to none, even or odd. For error-free communications to occur, the CPC400 and any other device must have the same parity setting.
- **Hardware Protocol:** PC and controller must use the same protocol, or a converter must be used. The controller is typically configured for EIA/TIA-232 when it is shipped. See *Changing the Hardware Communications Protocol on page 157* to change between EIA/TIA-232 and EIA/TIA-485. To communicate with more than one controller, or when more than 50 feet of cable is required, use EIA/TIA-485. Even for a single controller, you may use EIA/TIA-485 and an optically isolating converter to eliminate ground loops.
- **Converter:** Make sure that the 232-to-485 converter is powered, configured and wired correctly.
- **Cables:** Check continuity by placing a resistor across each pair of wires and measuring the resistance with an ohmmeter at the other end.

Software Problems

If the controller and serial communications connections seem to be working correctly, but you are still not getting the result you expect, consult the documentation for the software program you are using.

Anafaze WatView and LogicPro software come with context-sensitive help explaining operation of the software. You can press the F1 key to get information related to the part of the program you are using.

Clearing the RAM

Clearing the random access memory (RAM) returns all controller settings to their defaults. All stored jobs are also cleared from controller memory.

To clear the RAM:

1. Make a record of all controller settings.
2. Switch off power to the controller.
3. Press and hold ▼.
4. Switch on power to the controller while still holding ▼.
5. When you see the prompt *Clear RAM?*, release ▼ and press ▶.

6. Restore the controller settings.

If you have a stand-alone system, you must manually re-enter your original parameters. If you have a computer-supervised system with WatView software, you can save a copy of your parameters to a job file and then reload them into the controller.

Replacing the Flash Memory Chip

This procedure requires a Phillips screwdriver and an IC extraction tool or jeweler's flathead screwdriver.

CAUTION! ***The flash memory chip and other components are sensitive to damage from electrostatic discharge (ESD). To prevent ESD damage, use an ESD wrist strap or other antistatic device.***

NOTE! ***Replacing the flash memory chip results in full erasure of RAM. Make a record of all parameters before changing the flash memory chip.***

1. Make a record of controller parameters.
2. Switch off power to the controller.
3. Disconnect input power to the controller.
4. Remove the four screws from the sides of the controller front bezel.

5. Remove the electronics assembly from the case, as shown in *Figure 6.1*.

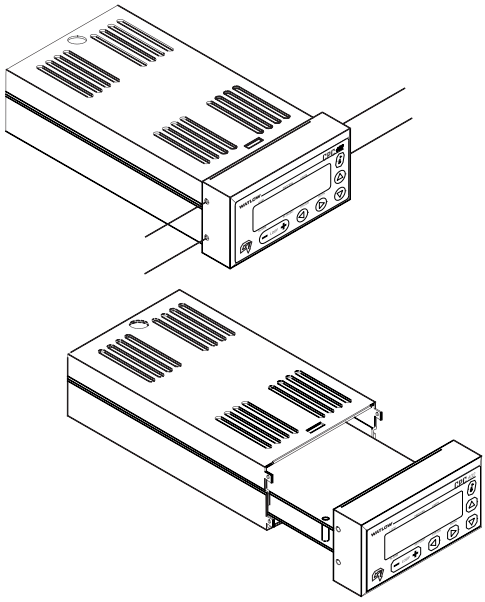


Figure 6.1 Removal of Electronics Assembly from Case

6. Unscrew the four screws at the corners of the top board and carefully unplug this board to access the bottom board. *Figure 6.2* shows the screws to remove:

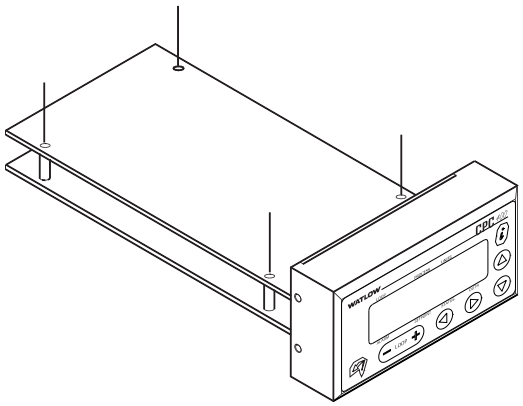


Figure 6.2 Screw Locations on PC Board

7. Locate the flash memory chip on the circuit board. The flash memory chip is a 32-pin socketed chip that is labeled with the model, version and checksum.

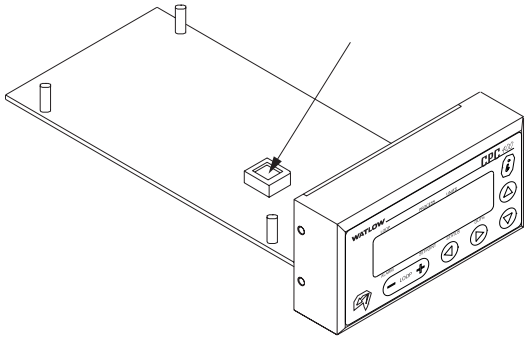


Figure 6.3 Location of Flash Memory Chip

8. Remove the existing flash memory chip from its socket with an IC extraction tool or a jeweler's flathead screwdriver.

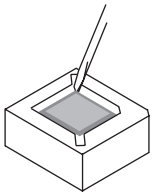


Figure 6.4 Removal of Flash Memory Chip

9. Carefully insert the new flash memory chip into the socket. Make sure that the chip is oriented so that its notch fits in the corresponding corner of the socket.
10. Reverse steps 2 through 6 to reassemble the unit.
11. Power up the controller.
12. Re-enter parameters.

Changing the Hardware Communications Protocol

To switch between EIA/TIA-232 and EIA/TIA-485, change the jumpers as shown in *Figure 6.5*.

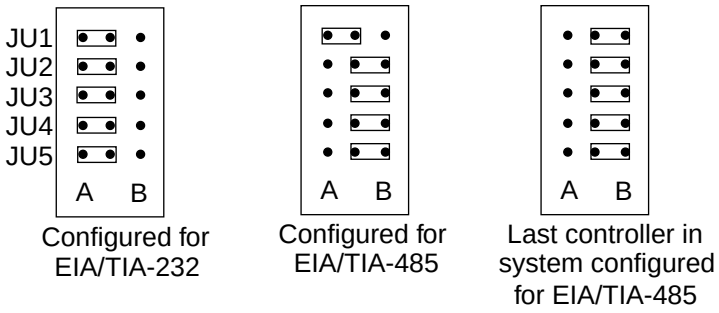


Figure 6.5 Jumper Configurations

You will need tweezers and a Phillips head screwdriver to switch between EIA/TIA-232 and EIA/TIA-485:

1. Power down the unit.
2. Remove the controller's metal casing. See *Replacing the Flash Memory Chip on page 154* for step-by-step instructions.
3. Find jumpers JU2, JU3, JU4, and JU5 on the board.
4. Use tweezers to carefully grasp the jumpers and gently slide them off the pins.
5. Use tweezers to gently slide jumpers JU2, JU3, JU4 and JU5 onto the correct pins (see *Figure 6.5*).
6. If you are configuring the controller as the last device on an EIA/TIA-485 network, move JU1 to the B position.
7. Reassemble the controller.

Installing Scaling Resistors

Resistors are installed for all inputs on the CPC400. Inputs with signal ranges between -10 and +60 mV use 0 Ω resistors in the RC position only. All other input signals require special input scaling resistors.

CAUTION! ***Scaling resistors are soldered to the circuit board. Only qualified technicians should attempt to install or remove these components. Improper techniques, tools or materials can result in damage to the controller that is not covered by the warranty.***

Input Circuit

The CPC400 can accept differential thermocouple, mVdc, Vdc, mAdc and RTD inputs. Unless ordered with special inputs these controller accept only signals within the standard range -10 to +60 mV⎓ (dc).

To accommodate other signals, the input circuit must be modified. When configured for thermocouple inputs, 0 Ω resistors are installed in all RC locations. To accommodate voltage signals outside the standard range, milliamp current signals or RTDs, resistors are added or replaced to scale the signals to the standard range. These resistor can be installed by Watlow Anafaze or by a qualified electronics technician using scaling resistors supplied by Watlow Anafaze.

Figure 6.6 shows the input circuit for one differential analog input. See *Current Inputs on page 159* through *RTD Inputs on page 161* for specific instructions and resistor values for voltage, current and RTD inputs.

NOTE! ***When adding your own scaling resistors to the controller, for voltage and RTD inputs you will have to carefully remove one of the RC resistors in order to install the resistor listed in the table.***

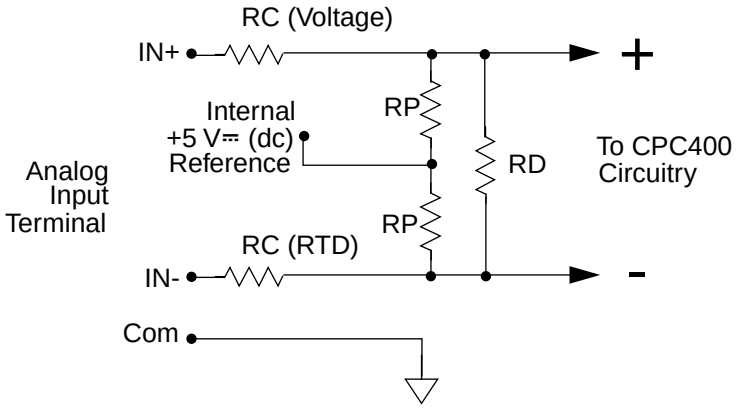


Figure 6.6 Input Circuit

Current Inputs

For each current input, you must install a resistor. The value of the resistor must be correct for the expected input range. Install the resistor in the listed resistor pack (RP) location. Note the resistor pack locations have three through-holes. Install the resistor as shown in the illustration below.

Table 6.3 Resistor Values for Current Inputs

Input Range	Resistor Value RD
0 to 10 mA	6.0 Ω
0 to 20 mA	3.0 Ω

Resistor tolerance: ±0.1%

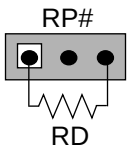


Table 6.4 Resistor Locations for Current Inputs

Loop	Resistor Location RD
1	RP1
2	RP2
3	RP3
4	RP4

Loop	Resistor Location RD
5	RP5
6	RP6
7	RP7
8	RP8

Voltage Inputs

For each voltage input, you must install two resistors. The resistances must be correct for the expected input range. Note the resistor pack (RP) locations have three through-holes. Install the RD resistor as indicated in the illustration below.

Table 6.5 Resistor Values for Voltage Inputs

Input Range	Resistor Values	
	RC	RD
0 to 100mV⎓ (dc)	499 Ω	750 Ω
0 to 500mV⎓ (dc)	5.49 kΩ	750 Ω
0 to 1V⎓ (dc)	6.91 kΩ	442.0 Ω
0 to 5V⎓ (dc)	39.2 kΩ	475 Ω
0 to 10V⎓ (dc)	49.9 kΩ	301.0 Ω
0 to 12V⎓ (dc)	84.5 kΩ	422.0 Ω

Resistor tolerance: ±0.1%

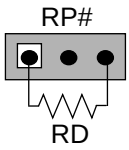


Table 6.6 Resistor Locations for Voltage Inputs

Loop	Resistor Locations	
	RC	RD
1	R58	RP1
2	R56	RP2
3	R54	RP3
4	R52	RP4
5	R50	RP5
6	R48	RP6
7	R46	RP7
8	R44	RP8

RTD Inputs

For each RTD input, you must install three resistors: RA, RB, and RC. The resistance must be correct for the expected input range. RA and RB are a matched pair of resistors. Install them in the resistor pack (RP) locations as shown in the illustration below.

Resistor values:

- RA/RB: 25 kΩ
- RC: 18.2 Ω

Resistor tolerances:

- RA/RB: Matched to 0.02% (±5 ppm/°C) with absolute tolerance of 0.1% (±25 ppm/°C)
- RC: Accurate to 0.05% (±5ppm/°C)

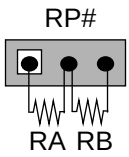


Table 6.7 Resistor Locations for RTD Inputs

Loop	Resistor Locations	
	RA/RB	RC
1	RP1	R57
2	RP2	R55
3	RP3	R53
4	RP4	R51
5	RP5	R49
6	RP6	R47
7	RP7	R45
8	RP8	R43

Scaling and Calibration

The controller provides offset calibration for thermocouple, RTD, and other fixed ranges, and offset and span (gain) calibration for process and pulse inputs. In order to scale the input signal, you must:

1. Install appropriate scaling resistors. (Contact the Customer Service Department at Watlow Anafaze for more information about installing scaling resistors.)
2. Enter the input range at the *Disp format* parameter in the *Input* menu. The smallest possible range is -0.9999 to 3.0000; the largest possible range is -9999 to 30000.
3. Enter the appropriate scaling values for your process. See *Setting Up a Process or Pulse Input on page 58*.

Configuring Serial DAC Outputs

On the Serial DAC, the voltage and current output is jumper-selectable. Refer to *Figure 6.7*. Configure the jumpers as indicated on the Serial DAC label.

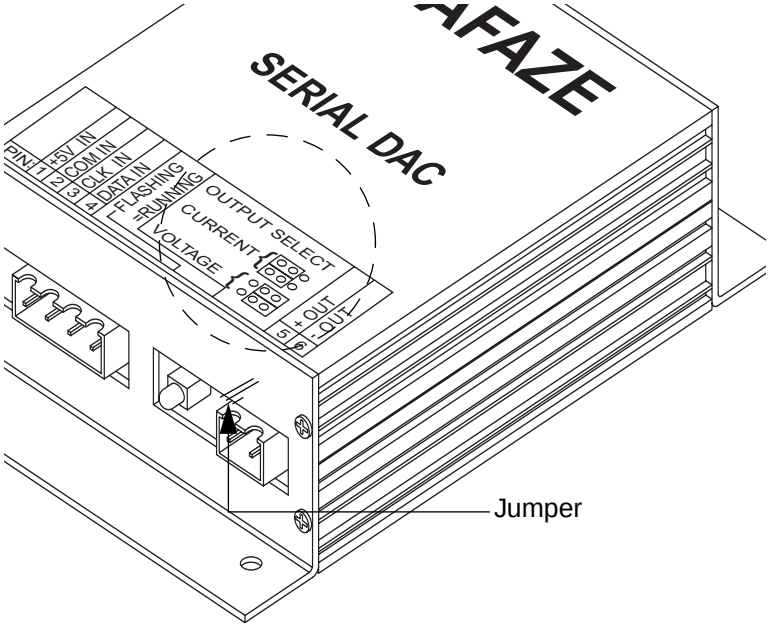


Figure 6.7 Serial DAC Voltage and Current Jumper Positions

Configuring Dual DAC Outputs

Dual DAC modules ship with both of the outputs configured for the signal type and span that were ordered. The module contains two independent circuits (DAC 1 and DAC 2). These circuits can be configured for different output types. Remove the board from the housing and set the jumpers. The odd-numbered jumpers determine the signal from DAC 1; the even-numbered jumpers determine the output from DAC 2.

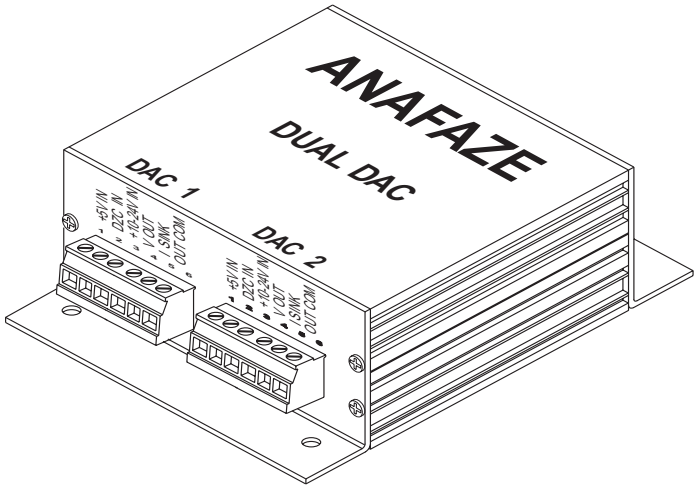


Figure 6.8 Dual DAC

Table 6.8 Dual DAC Jumper Settings

Output Type	Jumper Settings						
	1/2	3/4	5/6	7/8	9/10	11/12	13/14
0 to 5V⎓ (dc)	B	A	A	O	B	A	O
0 to 10V⎓ (dc)	B	A	A	O	B	O	O
4 to 20 mA	O	A	B	A	A	O	A

A = Load jumper in the "A" position, or load jumper if header has only two pins.

B = Load jumper in the "B" position.

O = Open. Do not load jumper.

1. Power down the system (if the Dual DAC is already installed and wired).
2. Ensure the DAC 1 and DAC 2 terminal blocks or associated wires are labeled such that you will know which terminal block connects to which side of the board if the module is already installed and wired.
3. Unplug the two terminal blocks.
4. Depending on the installation, you may need to unmount the Dual DAC module before proceeding. Remove the four screws from the end plate on the opposite side of the module from the terminal blocks.
5. If necessary, remove the two mounting screws holding the loosened end plate in place.
6. Slide the board out of the housing.
7. Set the jumpers for the two outputs as desired. See *Table 6.8*.
8. Replace the board such that the connectors extend through the opposite end plate. The board fits in the third slot from the bottom.
9. Reconnect the two terminal blocks to the DAC 1 and DAC 2 connectors.
10. Replace the end plate, end plate screws and, if necessary, mounting screws.
11. Check the wire connections to the DAC 1 and DAC 2 terminal blocks.
12. If necessary, change the wiring connections to the correct configuration for the new output type. See *Wiring the Dual DAC on page 39*.
13. Restore system power.

7

Specifications

This chapter contains specifications for the CPC400 series controllers, TB50 terminal board, Dual DAC module, Serial DAC module and the CPC400 power supply.

CPC400 System Specifications

This section contains CPC400 series controller specifications for environmental specifications and physical dimensions, inputs, outputs, the serial interface and system power requirements.

The controller consists of a processor module with a 50-terminal block (TB50) or a processor module with an 18-terminal block (TB18).

Table 7.1 Agency Approvals / Compliance

CE Directive	Electromagnetic Compatibility (EMC) Directive 89/336/EEC
UL and C-UL	UL 916, Standard for Energy Management Equipment File E177240

CPC400 Physical Specifications

Table 7.2 Environmental Specifications

Storage Temperature	-20 to 60°C
Operating Temperature	0 to 50°C
Humidity	10 to 95% non-condensing
Environment	The controller is for indoor use only

Table 7.3 Physical Dimensions

Weight	1.98 lbs	0.9 kg
Length*	8.0 inches	203 mm
Width	3.78 inches	96 mm
Height	1.96 inches	50 mm

* Without SCSI connector or with TB18 option.

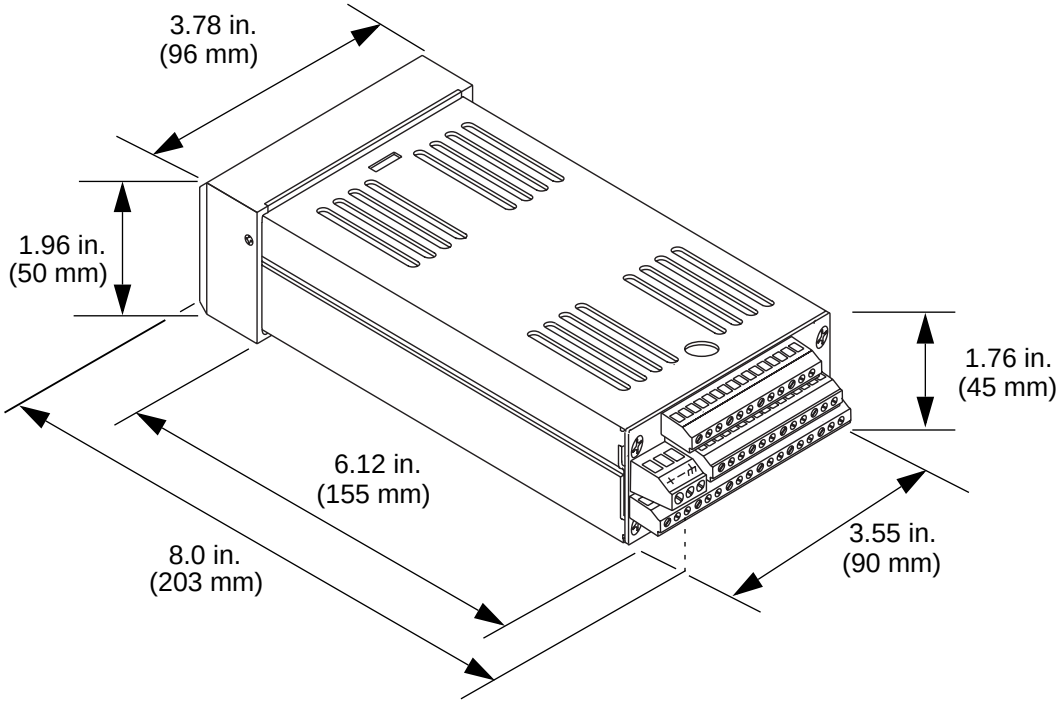


Figure 7.1 CPC400 Module Dimensions

Table 7.4 CPC400 with Straight SCSI

Length	9.6 inches	244 mm
Width	3.78 inches	96 mm
Height	1.96 inches	50 mm

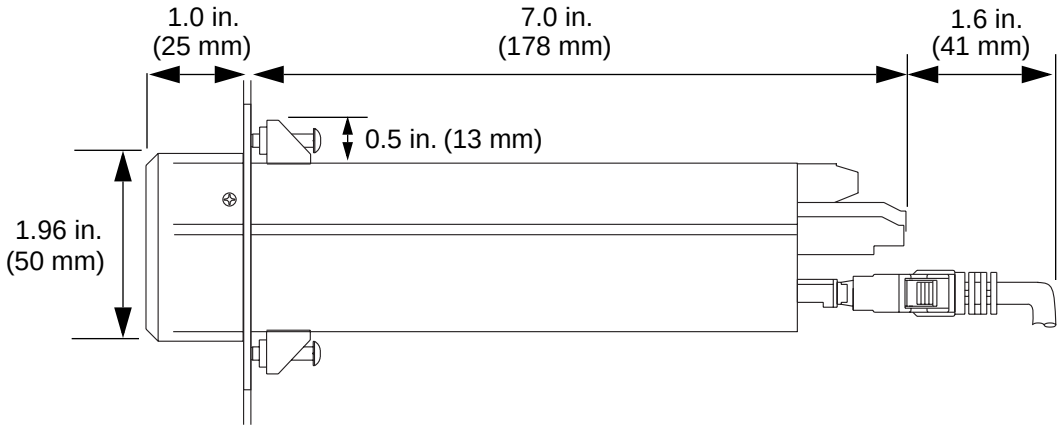


Figure 7.2 CPC400 Clearances with Straight SCSI Cable

Table 7.5 CPC400 with Right Angle SCSI

Length	8.6 inches	218 mm
Width	3.78 inches	96 mm
Height	1.96 inches	50 mm

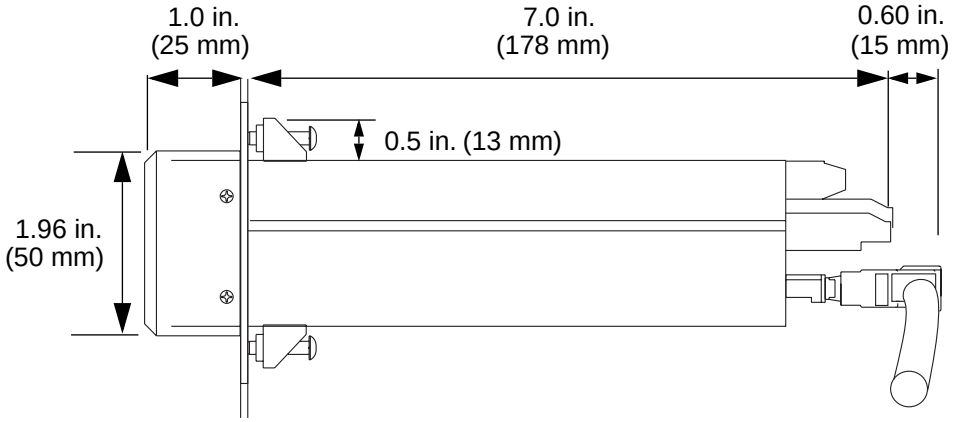


Figure 7.3 CPC400 Clearances with Right-Angle SCSI Cable

Table 7.6 CPC400 Connections

Power Terminals (TB2)	Captive screw cage clamp
Power Wire Gauge (TB2)	22 to 18 AWG (0.5 to 0.75 mm^2)
Power Terminal Torque (TB2)	4.4 to 5.3 in.-lb. (0.5 to 0.6 Nm)
Sensor Terminals (TB1)	Captive screw cage clamp
Sensor Wire Gauge (TB1)	Thermocouple: 20 AWG (0.5 mm^2) Process: 22 to 20 AWG (0.5 mm^2) Communications: 24 AWG (0.2 mm^2)
Sensor Terminal Torque (TB1)	4.4 to 5.3 in.-lb. (0.5 to 0.6 Nm)
Output Terminals (TB18)	Captive screw cage clamp
Output Wire Gauge (TB18)	Multiconductor cables: 24 AWG (0.2 mm^2) Single-wire: 22 to 18 AWG (0.5 to 0.75 mm^2)
Output Terminal Torque (TB18)	4.4 to 5.3 in.-lb. (0.5 to 0.6 Nm)
SCSI Connector	SCSI-2 female

TB50 Physical Specifications

Table 7.7 TB50 Physical Dimensions

Weight	0.32 lb.	0.15 kg
Length	4.1 inches	104 mm
Width	4.0 inches	102 mm
Height	1.5 inches	37 mm

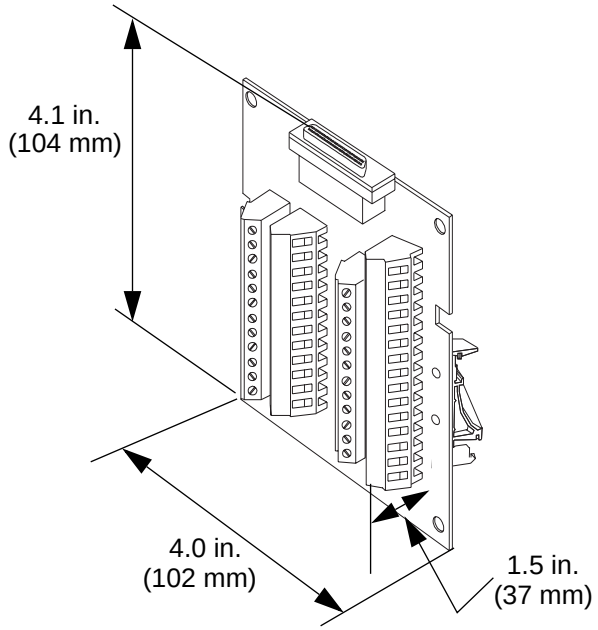


Figure 7.4 TB50 Dimensions

Table 7.8 TB50 Connections

Screw Terminal Torque	4.4 to 5.3 in.-lb. (0.5 to 0.6 Nm)
SCSI Connector on Board	SCSI-2 female
Output Terminals	Captive screw cage clamp
Output Wire Gauge	Multiconductor cables: 24 AWG ($0.2\ mm^2$) Single-wire: 22 to 18 AWG (0.5 to $0.75\ mm^2$)
Output Terminal Torque	4.4 to 5.3 in.-lb. (0.5 to 0.6 Nm)

Table 7.9 TB50 with Straight SCSI

Length	6.4 inches	163 mm
Width	4.0 inches	102 mm
Height	1.5 inches	37 mm

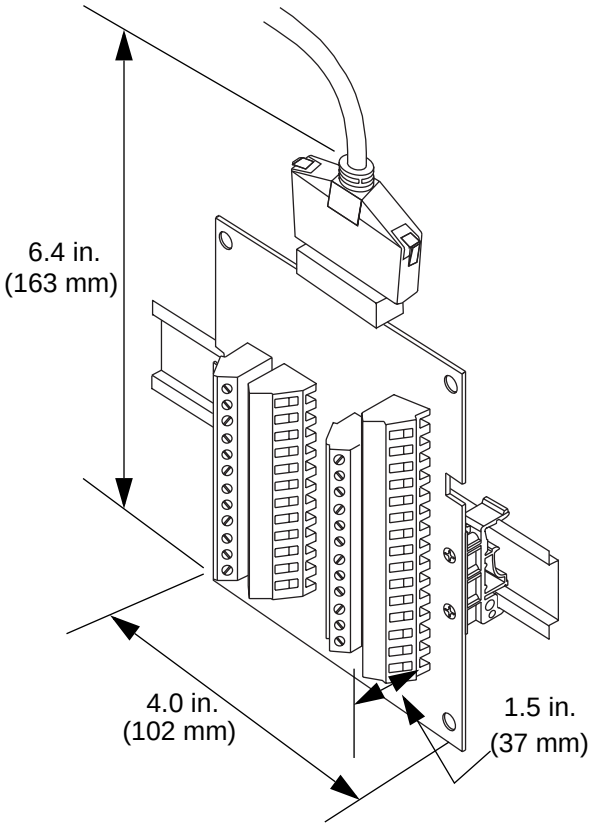


Figure 7.5 TB50 Dimensions with Straight SCSI Cable

Table 7.10 TB50 with Right Angle SCSI

Length	5.4 inches	137 mm
Width	4.0 inches	102 mm
Height	1.5 inches	37 mm

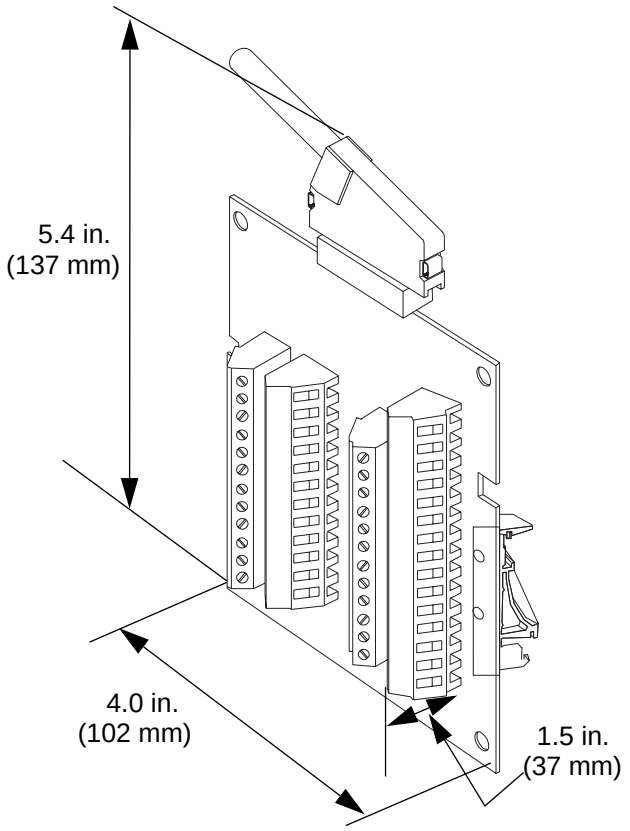


Figure 7.6 TB50 Dimensions with Right-Angle SCSI Cable

Inputs

The controller accepts analog sensor inputs which are measured and may be used as feedback for control loops. It also accepts digital (TTL) inputs which may be used to trigger certain firmware features.

Table 7.11 Analog Inputs

Number of Control Loops	CPC404: 5 CPC408: 9
Number of Analog Inputs	CPC404: 4 with full range of input types, plus one pulse CPC408: 8 with full range of input types, plus one pulse
Input Sampling Rate	CPC404: 6 Hz (167 ms) at 60 Hz; 5 Hz (200 ms) at 50 Hz CPC408: 3 Hz (333 ms) at 60 Hz; 2.5 Hz (400 ms) at 50 Hz
Transient Voltage Isolation	Between inputs: 280 V~ (ac) Input-to-digital circuitry: 530 V~ (ac)
Maximum Common Mode Voltage	5 V from input to analog common
Common Mode Rejection (CMR)	>60 dB dc to 1 kHz, and 120 dB at selected line frequency
A/D Converter	Integrates voltage to frequency
Resolution	0.006%, greater than 14 bits (internal)
Input Range	-10 to +60 mV, or 0 to 12 V with scaling resistors
Accuracy	0.03% of full scale (60 mV) at 25°C
	0.08% of full scale (60 mV) at 0 to 50°C
Calibration	Automatic zero and full scale
Open Thermocouple Detection	Pulse type for upscale break detection
Milliampere Inputs	0 to 20 mA (3 Ω resistance) or 0 to 10 mA (6 Ω resistance), with scaling resistors
Special Input Voltage Ranges Available	0 to 12V, 0 to 10V, 0 to 5V, 0 to 1V, 0 to 500 mV, 0 to 100 mV with scaling resistors
Source Impedance	For 60 mV thermocouple, measurements are within specification with up to 500 Ω resistance For other types of analog signals, the maximum source impedance is 5000 Ω

Table 7.12 Pulse Inputs

Number	1
Frequency Range	0 to 2000 Hz
Input Voltage Protection	Diodes to supply and common
Voltage Levels	<0.7V = Low >1.9V = High (TTL)
Maximum Switch Resistance to Pull Input Low	1.5 kΩ
Minimum Switch Off Resistance	30 kΩ

Table 7.13 Programmable Logic

Programming Languages	Ladder diagram, sequential function chart, function block diagram (IEC 1131-3)
Number of Instructions	7 logic instructions, 42 function block instructions
Memory	64K flash, nonvolatile
Program Execution	Logic program runs concurrently with closed-loop control
Read/Write Access	Controller I/O and closed-loop control parameters
Logic Programming Software	LogicPro
Programming Environment	Windows 95, Windows 98, Windows NT, Windows 2000

Table 7.14 Thermocouple Range and Resolution

Thermocouple Type	Range in ˚F	Range in ˚C	Accuracy* at 25°C Ambient		Accuracy* at 0 to 50°C Ambient	
			˚F	˚C	˚F	˚C
J	-350 to 1400	-212 to 760	±2.2	±1.2	±3.3	±1.8
K	-450 to 2500	-268 to 1371	±2.4	±1.3	±3.8	±2.1
T	-450 to 750	-268 to 399	±2.9	±1.6	±5.8	±3.2
S	0 to 3200	-18 to 1760	±5.0	±2.8	±8.8	±4.9
R	0 to 3210	-18 to 1766	±5.0	±2.8	±8.8	±4.9
B	150 to 3200	66 to 1760	±7.2	±4.0	±22.1	±12.3
E	-328 to 1448	-200 to 787	±1.8	±1.0	±2.9	±1.6

* True for 10 percent to 100 percent of span except type B, which is specified for 800°F to 3200°F.

Table 7.15 RTD Range and Resolution

Range in ˚F	Range in ˚C	Resolution in ˚C	Measurement Temperature in ˚C	Accuracy at 25˚C Ambient		Accuracy at 0 to 50˚C Ambient	
				˚F	˚C	˚F	˚C
-328.0 to 1150.0	-200.0 to 621.1	0.07	25	0.9	0.5	1.2	0.5
			400	2.7	1.5	4.1	2.2

Table 7.16 Input Resistance for Voltage Inputs

Range	Input Resistance
0 to 12V	85 kΩ
0 to 10V	50 kΩ
0 to 5V	40 kΩ
0 to 1V	7.4 kΩ
0 to 500 mV	6.2 kΩ
0 to 100 mV	1.2 kΩ

Table 7.17 Digital Inputs

Number	8
Configuration	8 selectable for output override, remote job selection or programmable logic
Input Voltage Protection	Diodes to supply and common. Source must limit current to 10 mA for overvoltage conditions
Voltage Levels	<1.3V = Low >3.7V = High (TTL) 5V maximum, 0 V minimum
Maximum Switch Resistance to Pull Input Low	1 kΩ
Minimum Switch Off Resistance	11 kΩ
Response Time	50 ms (AC line frequency set to 60 Hz) 60 ms (AC line frequency set to 50 Hz)

Outputs

The controller directly accommodates switched dc and open-collector outputs only. These outputs can be used to control a wide variety of loads. They are typically used to control solid-state relays or other power switching devices which, in turn, devices such as heaters. They may also be used to signal another device of an alarm condition in the controller.

Analog outputs may be accomplished by using Dual DAC or Serial DAC modules in conjunction with one of the control outputs.

An open-collector CPU watchdog output is also provided so that an external device can monitor the CPU state.

Analog Outputs

No direct analog outputs are provided.

The digital outputs may be used in conjunction with Dual DAC or Serial DAC modules to provide analog signals. See *Dual DAC Specifications on page 178* and *Serial DAC Specifications on page 180*.

Digital Outputs

Table 7.18 Digital Outputs Control / Alarm

Number	35
Operation	Open collector output; ON state sinks to logic common
Function	34 Outputs selectable as closed-loop control, alarms or programmable logic. 1 global alarm output
Number of Control Outputs per PID Loop	2 (maximum)
Control Output Types	Time proportioning, distributed zero crossing, Serial DAC or on/off. All independently selectable for each output. Heat and cool control outputs can be individually disabled for use as alarm outputs
Time Proportioning Cycle Time	1 to 255 seconds, programmable for each output
Control Action	Reverse (heat) or direct (cool), independently selectable for each output
Off State Leakage Current	<0.01 mA to dc common
Maximum Current	60 mA for each output. 5V power supply (from the processor module) can supply up to 350 mA total to all outputs
Maximum Voltage Switched	24V⎓ (dc)

Table 7.19 CPU Watchdog Output

Number	1
Operation	Open collector output; ON state sinks to logic common
Function	Monitors the processor module microprocessor
Maximum Current	10 mA (5V power supply in the processor module can supply up to 350 mA total to all outputs)
Maximum Voltage Switched	5V⎓ (dc)

Table 7.20 5V⎓ (dc) Output (Power to Operate Solid-State Relays)

Voltage	5V⎓ (dc)
Maximum Current	350 mA

Table 7.21 CPC400 Serial Interface

Type	EIA/TIA-232 3-wire or EIA/TIA-485 4-wire
Isolation	530V~ (ac)
Baud Rate	2400, 9600 or 19200, user selectable
Error Check	Cyclic redundancy check (CRC)
Number of Controllers	1 with EIA/TIA-232 communications Up to 32 with EIA/TIA-485 communications
Protocol	Modbus RTU

Table 7.22 CPC400 Power

Voltage	12 to 24V⎓ (dc) +/-15%
Maximum Current	1 A
Power Common to Frame Ground Maximum Potential	40V

CPC400 Power Supply

These specifications are for the power supply typically shipped. If that power supply is not available, a similar power supply may be substituted. If the dimensions or other specifications deviate significantly, the shipment will include updated specifications.

Table 7.23 Power Supply Environmental Specifications

Storage Temperature	-20 to 60°C
Operating Temperature	0 to 50°C
Humidity	10 to 95% non-condensing

Table 7.24 Power Supply Agency Approvals / Compliance

CE Directive	LVD 93/68 EEC

Table 7.25 Power Supply Physical Specifications

Weight	1.2 lb.	0.6 kg
Length	6.9 inches	175 mm
Width	3.9 inches	99 mm
Height	1.4 inches	36 mm

Table 7.26 Power Supply with Mounting Bracket

Length	8.1 inches	206 mm
Width	3.9 inches	99 mm
Height	1.4 inches	36 mm

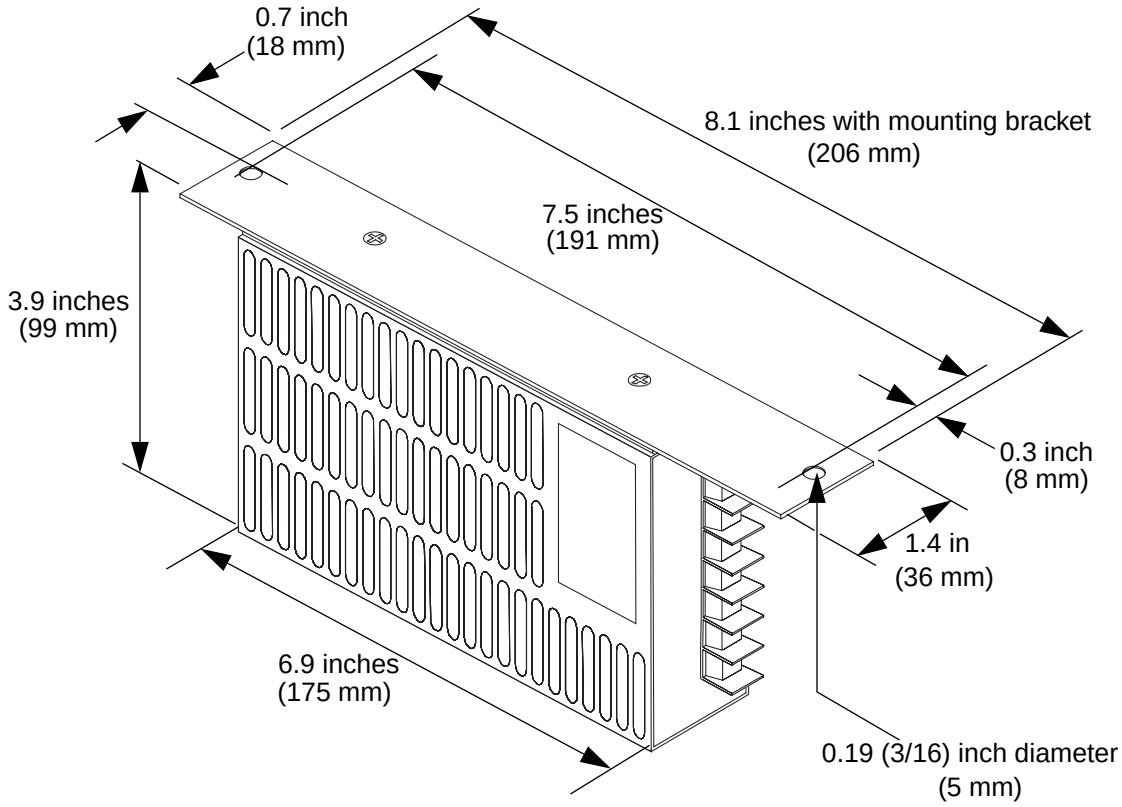


Figure 7.7 Power Supply Dimensions (Bottom View)

Table 7.27 Power Supply Inputs and Outputs

Input Voltage	120/240V~ (ac) at 0.75 A, 50/60 Hz
Output Voltage (V1)	5V⎓ (dc) at 4 A
Output Voltage (V2)	15V⎓ (dc) at 1.2 A

Dual DAC Specifications

The Watlow Anafaze Dual DAC (digital-to-analog converter) is an optional module for the CPC400 series controller. The Dual DAC converts a distributed zero crossing (DZC) output signal to an analog process control signal. Watlow Anafaze provides the following version of the Dual DAC:

- 4 to 20 mA⎓ (dc)
- 0 to 5V⎓ (dc)
- 0 to 10V⎓ (dc)
- Dual DAC Environmental Specifications

Storage Temperature	-20 to 60°C
Operating Temperature	0 to 50°C
Humidity	10 to 95% non-condensing

Table 7.28 Dual DAC Physical Specifications

Weight	0.42 lb.	0.19 kg
Length	4.4 inches	112 mm
Width	3.6 inches	91 mm
Height	1.8 inches	44 mm

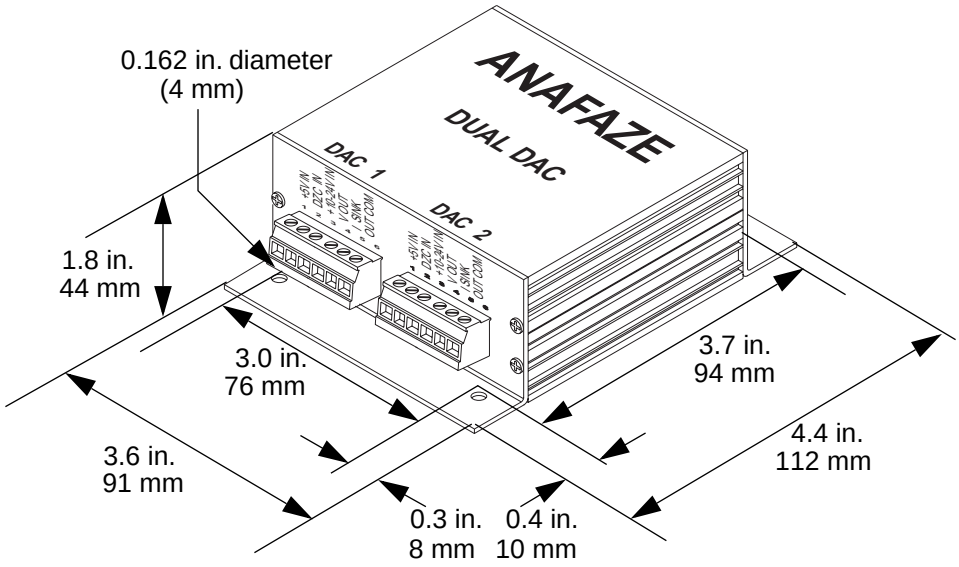


Figure 7.8 Dual DAC Dimensions

Dual DAC Inputs

The Dual DAC accepts an open-collector signal from the CPC400 controller and the power from an external power supply. See *Table 7.29*.

Table 7.29 Dual DAC Power Requirements

Parameter	Description
Voltage	12 to 24V⎓ (dc)
Current	100 mA @ 15V⎓ (dc)

Dual DAC Analog Outputs

Table 7.30 Dual DAC Specifications by Output Range

Version	4 to 20 mA	0 to 5V	0 to 10V	Units
Gain Accuracy	± 6	± 6	± 6	percent
Output Offset	± 0.75	± 0.75	± 0.75	percent of full scale range
Ripple	1.6	1.6	1.6	percent of full scale range
Response Time	2	2	2	seconds
Maximum Current Output	20	10	10	mA⎓ (dc)
Load Resistance (12V)	250 maximum	500 minimum	1000 minimum	Ohms
Load Resistance (24V)	850 maximum	n/a	n/a	Ohms

Serial DAC Specifications

Watlow Anafaze offers a Serial DAC for precision open-loop analog outputs. The Serial DAC is jumper-selectable for a 0 to 10V⎓ (dc) or 4 to 20 mA output. Multiple Serial DAC modules can be used with one CPC400. The Serial DAC carries a CE mark.

Table 7.31 Serial DAC Environmental Specifications

Storage Temperature	-20 to 60°C
Operating Temperature	0 to 70°C
Humidity	10 to 95% non-condensing

Table 7.32 Serial DAC Physical Specifications

Weight	0.76 lb.	0.34 kg
Length	5.4 inches	137 mm
Width	3.6 inches	91 mm
Height	1.8 inches	44 mm

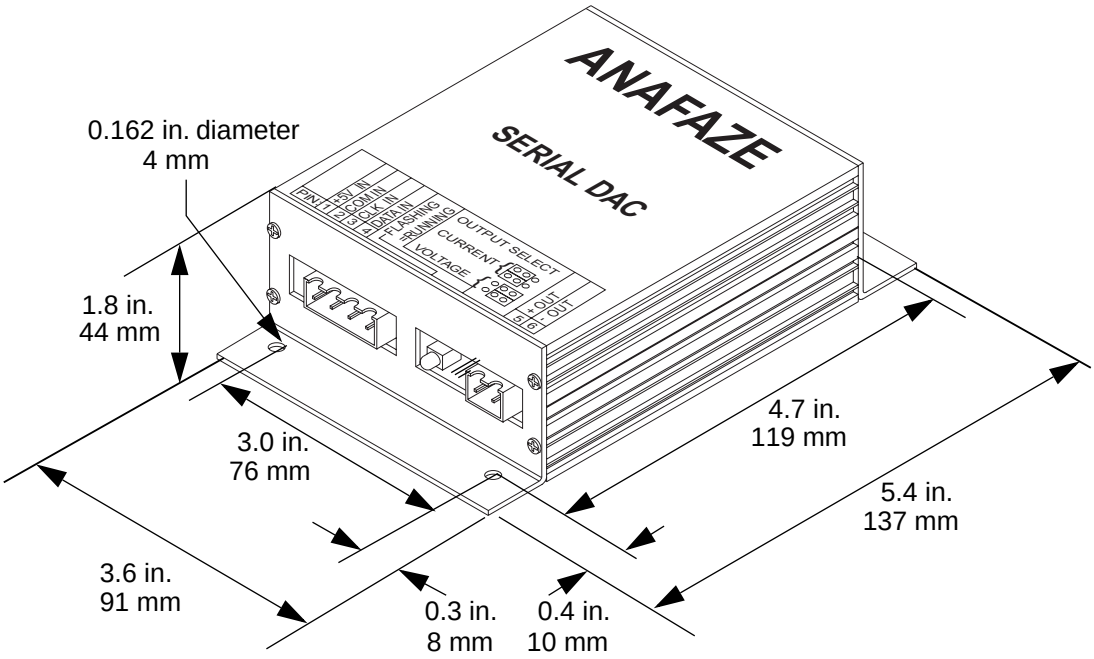


Figure 7.9 Serial DAC Dimensions

Table 7.33 Serial DAC Agency Approvals / Compliance

CE Directive	Electromagnetic Compatibility (EMC) directive 89/336/EEC
UL and C-UL	UL 916 Standard for Energy Management Equipment File E177240

Serial DAC Inputs

The Serial DAC requires a proprietary serial data signal and the clock signal from the CPC400 via the TB50. Any control output can be configured to provide the data signal. The Serial DAC also requires a 5 V⎓ (dc) power input.

Table 7.34 Serial DAC Inputs

Data	4 mA maximum to DC COM Open collector or HC CMOS logic levels
Clock	0.5 mA maximum to DC COM Open collector or HC CMOS logic levels

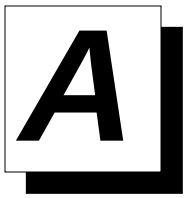
Table 7.35 Serial DAC Power Requirements

Voltage	4.75 to 5.25 V⎓ (dc) @ 300 mA maximum
Current	210 mA typical @ 20 V⎓ (dc) out

Serial DAC Analog Outputs

Table 7.36 Serial DAC Analog Output Specifications

Absolute Maximum Common Mode Voltage	Measured between output terminals and controller common: 1000V
Resolution	15 bits (plus polarity bit for voltage outputs) (0.305 mV for 10V output range) (0.00061 mA for 20 mA output range)
Accuracy (Calibrated for Voltage Output)	For voltage output: ± 0.005V (0.05% at full scale) For current output: ± 0.1 mA (0.5% at full scale)
Temperature coefficient	440 ppm/ °C typical
Isolation Breakdown Voltage	1000V between input power and signals
Current	0 to 20 mA (500 Ω load max.)
Voltage	0 to 10V⎓ (dc) with 10 mA source capability
Output Response Time	1 ms typical
Update Rate	Once per controller A/D cycle nominal. Twice per second maximum for 60 Hz clock rate. Output changes are step changes due to the fast time constant. All Serial DAC loop outputs are updated at the same time.



Appendix A: Modbus Protocol

The serial communications port on the CPC400 supports the Modbus RTU protocol. This protocol defines the message structure for all communication packets. The protocol is the same for both EIA/TIA-232 and EIA/TIA-485 serial interfaces. Modbus ASCII is not supported. Up to 32 CPC400 controllers may be connected on a network.

Watlow Anafaze offers a Modbus driver for use with Windows-based software applications that communicate with the CPC400. Using that driver makes it unnecessary for the programmer to understand and implement the Modbus protocol.

Master-Slave Model

Controllers communicate using a master-slave model, in which only one device (the master) can initiate transactions (called “queries”). The other devices (slaves) respond by supplying the requested data to the master, or by taking the action requested in the query. Typical master devices include host PCs and operator panels. The CPC400 is a slave device.

The master can address individual slaves, or initiate a broadcast message to all slaves. Slaves return a message (called a “response”) to queries that are addressed to them individually. Responses are not returned to broadcast queries from the master.

The Modbus protocol establishes the format for the master’s query by placing into it the device (or broadcast) address, a function code defining the requested action, any data to be sent, and an error-checking field. The slave’s response message is also constructed using Modbus protocol. It contains fields confirming the action taken, any data to be returned, and an error-checking field. If an error oc-

curred in receipt of the message, or if the slave is unable to perform the requested action, the slave will construct an error message and send it as its response.

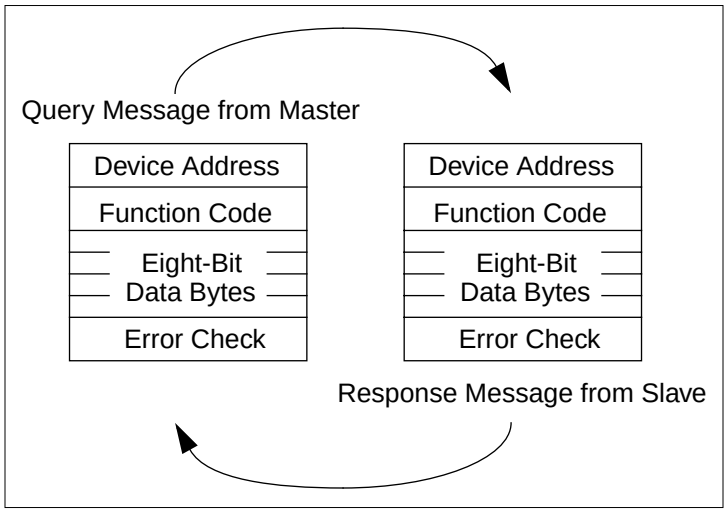


Figure A.1 Query - Response Cycle

Query

The function code in the query tells the addressed slave device what kind of action to perform. The data bytes contain any additional information that the slave will need to perform the function. For example, function code 03 will query the slave to read holding registers and respond with their contents. The data field must contain the information telling the slave which register to start at and how many registers to read. The error check field provides a method for the slave to validate the integrity of the message contents.

Response

If the slave makes a normal response, the function code in the response is an echo of the function code in the query. The data bytes contain the data collected by the slave, such as register values or status. If an error occurs, the function code is modified to indicate that the response is an error response, and the data bytes contain a code that describes the error. The error check field allows the master to confirm that the message contents are valid.

Modbus ASCII and RTU Modes

The Modbus protocol supports two distinct serial transmission modes: ASCII and RTU. The mode determines how messages are framed and coded. Typically, ASCII is used for simple communication tasks or diagnostics while RTU is used where a more robust and efficient protocol is required. The CPC400 supports Modbus RTU mode only.

In ASCII mode, each character in a message string is composed of a hexadecimal character which is correlated to an ASCII character. For example, an ASCII message string contains the value of a process variable, 5500 (550.0 degrees). 5500 in an ASCII string is composed of 4 bytes, 35 35 30 30. 35 and 30 in hexadecimal equate to the characters "5" and "0" in the ASCII table respectively.

In RTU mode, the actual value is embedded in a message string. There is no translation to ASCII characters. This results in more compact message strings and efficient serial communications. The value 5500 in an RTU string is composed of its hexadecimal equivalent which is only 2 bytes, 15 7C.

Many host devices can communicate in either ASCII or RTU mode. However, it should be noted that some PLCs can only be an ASCII host.

Message Framing

Messages start with a silent interval of at least 3.5 character times. This is most easily implemented as a multiple of character times at the baud rate that is being used on the network (shown as T1-T2-T3-T4 in *Figure A.2*). The first field then transmitted is the device address.

Networked controllers monitor the network bus continuously, including during the silent intervals. When the first field (the address field) is received, each device decodes it to find out if it is the addressed device.

Following the last transmitted character, a similar interval of at least 3.5 character times marks the end of the message. A new message can begin after this interval.

Similarly, if a new message begins earlier than 3.5 character times following a previous message, the receiving device will consider it a continuation of the previous message. This will set an error, as the value in the final CRC field will not be valid for the combined messages. An example message frame is shown in *Figure A.2*.

Start	Address	Function	Data	CRC Check	End
T1-T2-T3-T4	8 Bits	8 Bits	n X 8 Bits	16 Bits	T1-T2-T3-T4

Figure A.2 Example Message Frame

Address Field

The address field of a message frame contains eight bits. Valid slave device addresses are in the range of 0 to 247 decimal. The individual slave devices are assigned addresses in the range of 1 to 247. Address 0 is reserved for broadcast messages. The CPC400 controller currently supports only 32 devices. A master addresses a slave by placing the slave address in the address field of the message. When the slave sends its response, it places its own address in this address field of the response to let the master know which slave is responding.

Function Field

The function code field of a message frame contains eight bits. Valid codes are in the range of 1 to 255 decimal. Not all of these codes are applicable to CPC400 controllers. Current codes are described in *Function Codes on page 190*.

When a message is sent from a master to a slave device, the function code field tells the slave what kind of action to perform. For example, the function code might tell the slave to read the on/off states of a block of digital inputs or outputs, to read the data contents of a block of registers, or to read the diagnostic status of a controller.

When the slave responds to the master, it uses the function code field to indicate either a normal (error-free) response or that some kind of error occurred (called an exception response). For a normal response, the slave simply echoes the original function code. For an exception response, the slave returns a code that is equivalent to the original function code with its most significant bit set to a logic 1.

For example, a message from the master to slave to read a block of holding registers would have thisg function code:

0000 0011 Hexadecimal 03

If the slave device takes the requested action without error, it returns the same code in its response. If an exception occurs, it returns:

1000 0011 Hexadecimal 83

In addition to its modification of the function code for an exception response, the slave places a unique code into the data field of the response message. This tells the master what kind of error occurred, or the reason for the exception.

The master device's application program has the responsibility of handling exception responses. Typical processes are to post subsequent retries of the message, to try diagnostic messages to the slave, and to notify operators.

Data Field

The contents of the data field varies depending on whether messages originate from a master or slave. Data fields in slave messages consist of hexadecimal values.

Data fields of master messages contain additional information which the slave must use to take the action defined by the function code. This can include items like digital and register addresses, the quantity of items to be handled, and the count of actual data bytes in the field.

For example, if the master requests a slave to read a group of holding registers (function code 03), the data field specifies the starting register and how many registers are to be read.

If no error occurs, the data field of a response from a slave to a master contained the data requested. If an error occurs, the field contains an exception code that the master application can use to determine the next action to be taken.

The data field can be nonexistent (of zero length) in certain kinds of messages, where the function code alone specifies the action.

Error Checking Field

The error-checking field contains a 16-bit value implemented as two 8-bit bytes. The error check value is the result of a cyclical redundancy check (CRC) calculation performed on the message contents.

The CRC field is appended to the message as the last field in the message. When this is done, the low-order byte of the field is appended first, followed by the high-order byte. The CRC high-order byte is the last byte to be sent in the message.

Field Format

When messages are transmitted on standard Modbus serial networks, each character or byte is sent in this order (left to right):

Least Significant Bit…Most Significant Bit

The bit sequence is as follows:

- With parity checking:

Start	1	2	3	4	5	6	7	8	Parity	Stop

- Without parity checking

Start	1	2	3	4	5	6	7	8	Stop	Stop

Error Checking Methods

Modbus RTU use two kinds of error checking:

- Parity checking
- Frame checking (CRC)

Parity checking can be optionally applied to each character, while the frame checking is applied to the entire message. Both the character check and message frame check are generated in the master device and applied to the message contents before transmission. The slave device checks each character and the entire message frame during receipt.

The master is configured by the user to wait for a predetermined time-out interval before aborting the transaction. This interval is set to be long enough for any slave to respond normally. If the slave detects a transmission error, the message will not be acted upon. The slave will not construct a response to the master. Thus the time-out will expire and allow the master's program to handle the error. Note that a message addressed to a nonexistent slave device will also cause a time-out.

Parity Checking

You can configure controllers for even, odd or no parity checking. This will determine how the parity will be set in each character.

If you choose either even or odd parity, the quantity of bits that are set to 1 will be counted in the data portion of each character (8 bits). The parity bit will then be set to a 0 or 1 to result in an even or odd total of bits set to 1.

For example, suppose these eight data bits are contained in an RTU character frame:

1100 0101

Four bits are set to 1. If even parity is used, the frame's parity bit will be a 0, resulting in an even quantity of bits (four) set to 1. If odd parity is used, the parity bit will be set to 1, resulting in an odd quantity of bits (five) set to 1.

When the message is transmitted, the parity bit is calculated and applied to the frame of each character. The receiving device counts the quantity of bits set to 1 and sets an error if they are not the same as configured for that device. (All devices on the Modbus network must be configured to use the same parity check method.)

Note that parity checking can detect an error only if an odd number of bits are picked up or dropped in a character frame during transmission. For example, if odd parity checking is used, and two 1 bits are dropped from a character containing three 1 bits, the result is still an odd count.

If no parity checking is used, then the parity bit is not transmitted and no parity check is made. An additional stop bit is transmitted to fill out the character frame.

CRC Checking

All messages include an error-checking field that is based on a cyclical redundancy check (CRC) method. The CRC field checks the contents of the entire message. It is applied regardless of any parity check method used for the individual characters of the message.

The CRC field is two bytes, containing a 16-bit binary value. The CRC value is calculated by the transmitting device, which appends the CRC to the message. The receiving device recalculates a CRC during receipt of the message and compares the calculated value to the actual value it received in the CRC field. If the two values are not equal, an error results.

The CRC is started by first preloading a 16-bit register to all 1s. Then a process begins of applying successive 8-bit bytes of the message to the current contents of the register. Only the eight bits of data in each character are used for generating the CRC. Start and stop bits, and the parity bit if one is used, do not apply to the CRC.

During generation of the CRC, each 8-bit character is exclusive ORed with the register contents. Then the result is shifted in the direction of the least significant bit (LSB), with a 0 filled into the most significant bit (MSB) position. The LSB is extracted and examined. If the LSB was a 1, the register is then exclusive ORed with the preset, fixed value A001. If the LSB was a 0, no exclusive OR takes place.

This process is repeated until eight shifts have been performed. After the last shift, the next 8-bit byte is exclusive

ORed with the register's current value, and the process repeats for eight more shifts as described above. The final contents of the register, after all the bytes of the message have been applied, is the CRC value.

Function Codes

The listing below shows the function codes supported by the CPC400 controllers. Codes are listed in decimal.

Table A.1 Function Codes

Code Decimal	Name
01	Read Coil Status
02	Read Input Status
03	Read Holding Registers
04	Read Input Registers
05	Force Single Coil
06	Preset Single Register
08	Diagnostics
15	Force Multiple Coils
16	Preset Multiple Registers

Read Coil Status 01

Reads the on/off status of discrete outputs (0X references, coils) in the slave. Broadcast is not supported.

Read Input Status 02

Reads the on/off status of discrete inputs (1X references) in the slave. Broadcast is not supported.

Read Holding Registers 03

Reads the binary contents of holding registers (4X references) in the slave. Broadcast is not supported.

Read Input Registers 04

Reads the binary contents of input registers (3X references) in the slave. Broadcast is not supported.

Force Single Coil 05

Forces a single coil (0X reference) to either on or off. When broadcast, the function forces the same coil reference in all attached slaves.

Preset Single Register 06

Presets a value into a single holding register (4X reference). When broadcast, the function presets the same register reference in all attached slaves.

Diagnostics 08

Provides a series of tests for checking the communication system between the master and slave, or for checking various internal error conditions within the slave. Broadcast is not supported.

The function uses a two-byte subfunction code in the query to define the type of test to be performed. The slave echoes both the function code and subfunction code in a normal response.

Most of the diagnostic queries use a two-byte data field to send diagnostic data or control information to the slave. Some of the diagnostics cause data to be returned from the slave in a data field of a normal response.

Table A.2 on page 191 describes the diagnostics (08) subfunctions.

Table A.2 Diagnostics Subfunctions

Sub-function	Data Field		Description
	Query	Response	
00 00	Any	Echo Query Data	Return Query Data (00): Returns (loops back) the data passed in the query data field. The entire response message should be identical to the query.
00 01	00 00	Echo Query Data	Restart Communications (01): Initializes and restarts the slave's peripheral port, and clears all of its communications event counters. If the port is currently in listen-only mode, no response is returned. This function is the only one that brings the port out of listen-only mode. If the port is not currently in listen-only mode, a normal response is returned. This occurs before the restart is executed.
	FF 00	Echo Query Data	
00 02	00 00	Diagnostic Register Contents	Return Diagnostic Register (02): Returns the contents of the slave's 16-bit diagnostic register.

Sub-function	Data Field		Description
	Query	Response	
00 04	00 00	No Response	Force Listen-Only Mode (04): Forces the addressed slave to listen-only mode for Modbus communications. This isolates it from the other devices on the network, allowing them to continue communicating without interruption from the addressed slave. No response is returned. When the slave enters listen-only mode, all active communication controls are turned off. The ready watchdog timer is allowed to expire, locking the controls off. While in this mode, any Modbus messages addressed to the slave or broadcast are monitored, but the slave does not take any action or send any responses. The only function that will be processed after the mode is entered will be the Restart Communications Option function (function code 08, subfunction 01).
00 0A	00 00	Echo Query Data	Clear Counters (10): Clears all communication event counters. Counters are also cleared upon powerup.
00 0B	00 00	Total Message Count	Return Bus Message Count (11): Returns the quantity of messages that the slave has detected on the communications system since its last restart, clear-counters operation or powerup.
00 0C	00 00	CRC Error Count	Return Bus Communication Error Count (12): Returns the quantity of CRC errors encountered by the slave since its last restart, clear-counters operation or powerup.
00 0D	00 00	Exception Error Count	Return Bus Exception Error Count (13): Returns the quantity of Modbus exception responses returned by the slave since its last restart, clear-counters operation or powerup.
00 0E	00 00	Slave Message Count	Return Slave Message Count (14): Returns the quantity of messages addressed to the slave, or broadcast, that the slave has processed since its last restart, clear-counters operation or powerup.
00 0F	00 00	Slave No Response Count	Return Slave No-Response Count (15): Returns the quantity of messages addressed to the slave for which it returned no response (neither a normal response nor an exception response) since its last restart, clear-counters operation or powerup.

Force Multiple Coils 15

Forces each coil (0X reference) in a sequence of coils to either on or off. When broadcast, the function forces the same coil references in all attached slaves.

Preset Multiple Registers 16

Presets values into the sequence of holding registers (4X references). When broadcast, the function presets the same register references in all attached slaves.

Examples

Read Examples

The data read must be sequentially located. Table A.3 on page 193 shows the query and Table A.4 on page 193 shows the response:

Table A.3 Sample Packet for Host Query

Example	Slave Address	Function	Start Address		Number of Points		CRC	
			High Byte	Low Byte	High	Low		
Read process variable of loop 2 from controller with address 1	01	03	00	DE	00	01	E4	30
Read set points of loops 4 and 5 (500 and 600) from controller with address 3	03	03	00	CF	00	02	F5	D6

Table A.4 Sample Packet for Slave Response

Example	Slave Address	Function	Byte Count	Data 1		Data 2		CRC	
				High	Low	High	Low		
Read process variable of loop 2 from controller with address 1	01	03	02	06	40			BA	14
Read set points of loops 4 and 5 (500 and 600) from controller with address 3	03	03	04	01	F4	02	58	99	67

Write Examples

The data written is echoed back to the controller. The following examples show sample query and response packets.

Example 1

The host query (Table A.5 on page 194) uses the multiple-point write function to write a value of 20 to the proportional band for loop 1 in a controller with address 1. The slave responds (Table A.6 on page 194).

Table A.5 Sample Packet for Host Query

Slave Address	Function	Start Address		Data		CRC	
		High	Low	High	Low		
04	06	00	00	00	14	89	90

Table A.6 Sample Packet for Slave Response

Slave Address	Function	Start Address		Data		CRC	
		High	Low	High	Low		
04	06	00	00	00	14	89	90

Example 2

The host query (Table A.7 on page 194) uses the multiple-point write function to write the values 30, 40, and 50 to the proportional bands for loops 1 through 3 in a controller with address 1. The slave responds (Table A.8 on page 194).

Table A.7 Sample Packet for Host Query

Slave Addr.	Function	Start Address		No. of Registers		Byte Count	Data 1		Data 2		Data 3		CRC
		Hi	Lo	Hi	Lo		Hi	Lo	Hi	Lo	Hi	Lo	
01	10	00	00	00	03	06	00	1E	00	28	00	32	4F 5F

Table A.8 Sample Packet for Slave Response

Slave Address	Function	Start Address		Number of Registers		CRC
		High	Low	High	Low	
01	10	00	00	00	03	80 08

Glossary

A

AC
See Alternating Current.

AC Line Frequency
The frequency of the ac line power measured in Hertz (Hz), usually 50 or 60 Hz.

Accuracy
Closeness between the value indicated by a measuring instrument and a physical constant or known standards.

Action
The response of an output when the process variable is changed. See also Direct Action, Reverse Action.

Address
A numerical identifier for a controller when used in computer communications.

Alarm
A signal that indicates that the process has exceeded or fallen below a certain range around the set point. For example, an alarm may indicate that a process is too hot or too cold. See also Failed Sensor Alarm, Global Alarm, High Deviation Alarm, High Alarm, Loop Alarm, Low Deviation Alarm, Low Alarm.

Alarm Delay
The lag time before an alarm is activated.

Alternating Current (AC)
An electric current that reverses at regular intervals, and alternates positive and negative values.

Ambient Temperature
The temperature of the air or other medium that surrounds the components of a thermal system.

American Wire Gauge (AWG)
A standard of the dimensional characteristics of wire used to conduct electrical current or signals. AWG is identical to the Brown and Sharpe (B&S) wire gauge.

Ammeter
An instrument that measures the magnitude of an electric current.

Ampere (Amp, A)
A unit that defines the rate of flow of electricity (current) in the circuit. Units are one coulomb (6.25 x 1018 electrons) per second.

Analog Output
A continuously variable signal that is used to represent a value, such as the process value or set point value. Typical hardware configurations are 0 to 20mA, 4 to 20mA or 0 to 5V⎓ (dc).

Automatic Mode
A feature in which the controller sets PID control outputs in response to the process variable and the set point.

Automatic Reset
The integral function of a PI or PID temperature controller that adjusts the process temperature to the set point after the system stabilizes. The inverse of integral.

Autotune
A feature that automatically sets temperature control PID values to match a particular thermal system.

AWG
See American Wire Gauge.

B

Baud Rate
The rate of information transfer in serial communications, measured in bits per second.

BCD
Binary coded decimal. For BCD job loading, the binary states of three digital inputs are decoded as decimal numbers 1 to 8.

Bumpless Transfer
A smooth transition from automatic (closed loop) to manual (open loop) operation. The control output does not change during the transfer.

C

Calibration
The comparison of a measuring device (an unknown) against an equal or better standard.

Celsius
A temperature scale in which water freezes at 0° C and boils at 100° C at standard atmospheric pressure. The formula for conversion to the Fahrenheit scale is °F = (1.8 x °C) + 32. Formerly known as Centigrade.

Central Processing Unit (CPU)
The unit of a computing system that includes the circuits controlling the interpretation of instructions and their execution.

Circuit
Any closed path for electrical current. A configuration of electrically or electromagnetically-connected components or devices.

Closed Loop
A control system that uses a sensor to measure a process variable and makes decisions based on that feedback.

Cold Junction
Connection point between thermocouple metals and the electronic instrument.

Common Mode Rejection Ratio
The ability of an instrument to reject electrical noise, with relation to ground, from a common voltage. Usually expressed in decibels (dB).

Communications
The use of digital computer messages to link components. See also Serial Communications, Baud Rate.

Control Action
The response of the PID control output relative to the difference between the process variable and the set point. See also Direct Action, Reverse Action.

Current
The rate of flow of electricity. The unit of measure is the Ampere (A). 1 Ampere = 1 coulomb per second.

Cycle Time
The time required for a controller to complete one on-off-on cycle. It is usually expressed in seconds.

Cyclic Redundancy Check (CRC)
An error checking method in communications that provides a high level of data security.

D

DAC
See Digital-to-Analog Converter.

Data Logging
A method of recording a process variable over a period of time. Used to review process performance.

DC
See Direct Current.

Default Parameters
The programmed instructions that are permanently stored in the microprocessor software.

Derivative Control (D)
The last term in the PID algorithm. Action that anticipates the rate of change of the process and compensates to minimize overshoot and undershoot. Derivative control is an instantaneous change of the control output in the same direction as the proportional error. This is caused by a change in the process variable that decreases over the time of the derivative. The derivative is expressed in seconds.

Deutsche Industrial Norms (DIN)
A set of technical, scientific and dimensional standards developed in Germany. Many DIN standards have worldwide recognition.

Deviation Alarm
See High Deviation Alarm, Low Deviation Alarm.

Digital-to-Analog Converter (DAC)
A device that converts a numerical input signal to a signal that is proportional to the input in some way.

DIN
See Deutsche Industrial Norms.

Direct Action
An output control action in which an increase in the process variable causes an increase in the output. Usually used with cooling applications.

Direct Current (DC)
An electric current that flows in one direction.

Distributed Zero Crossing (DZC)
A form of digital output control in which the output on/off state is calculated for every ac line cycle. Power is switched at the zero cross, which reduces electrical noise. See also Zero Cross.

DZC
See Distributed Zero Crossing.

E

Earth Ground
A metal rod, usually copper, that provides an electrical path to the earth, to prevent or reduce the risk of electrical shock.

EIA/TIA
Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA). See also Serial Communications.

EIA/TIA-232 — A standard for interface between data terminal equipment and data communications equipment for serial binary data interchange. This is usually for communi-

cations over a short distance (50 feet [15 m] or less) and to a single device.

EIA/TIA-485 — A standard for electrical characteristics of generators and receivers for use in balanced digital multipoint systems. This is usually used to communicate with multiple devices over a common cable or where distances over 50 feet (15 m) are required.

Electrical Noise
See Noise.

Electromagnetic Interference (EMI)
Electrical and magnetic noise imposed on a system. There are many possible causes, such as switching ac power inside the sine wave. EMI can interfere with the operation of controllers and other devices.

Electrical-Mechanical Relays
See Relay, Electromechanical.

Emissivity
The ratio of radiation emitted from a surface compared to radiation emitted from a blackbody at the same temperature.

Engineering Units
Selectable units of measure, such as degrees Celsius or Fahrenheit, pounds per square inch, newtons per meter, gallons per minute, liters per minute, cubic feet per minute or cubic meters per minute.

F

Fahrenheit
The temperature scale that sets the freezing point of water at 32° F and its boiling point at 212° F at standard atmospheric pressure. The formula for conversion to Celsius is °C = 5/9 (°F - 32).

Failed Sensor Alarm
Warns that an input sensor no longer produces a valid signal.

Filter
Filters are used to handle various electrical noise problems.

Digital Filter — A filter that slows the response of a system when inputs change unrealistically or too fast. Equivalent to a standard resistor-capacitor (RC) filter

Digital Adaptive Filter — A filter that rejects high frequency input signal noise (noise spikes).

Heat/Cool Filter — A filter that slows the change in the response of the heat or cool output. The output responds to a step change by going to approximately 2/3 its final value within the numbers of scans that are set.

Frequency
The number of cycles over a specified period of time, usually measured in cycles per second. Also referred to as Hertz (Hz).

G

Gain
The amount of amplification used in an electrical circuit. Gain can also refer to the proportional (P) mode of PID.

Global Alarm
Warns that one or more alarm conditions exist by activating a digital output.

Ground
An electrical line with the same electrical potential as the surrounding earth. Electrical systems are usually grounded to protect people and equipment from shocks due to malfunctions. Also referred to as "safety ground."

H

Hertz (Hz)
Frequency, measured in cycles per second.

High Deviation Alarm
Warns that the process has risen more than a certain amount above set point. It can be used as either an alarm or control function.

High Power
(As defined by Watlow Anafaze) Any voltage above 24 V~ (ac) or V⎓ (dc) and any current level above 50 mA~ (ac) or mA⎓ (dc).

High Alarm
A signal that is associated with a set maximum value that can be used as either an alarm or boost control function.

HMI
Human-machine interface.

Hysteresis
Control Hysteresis — The range through which a variation of the input produces no noticeable change in the output. In the hysteresis, specific conditions can be placed on control output actions. Operators select the hysteresis. It is usually above the heating pro-

portional band and below the cooling proportional band.

Process Hysteresis — In heat/cool applications, the +/- difference between heat and cool. Also known as process deadband.

I

Input

Analog Input — An input that accepts process variable information.

Digital Input — An input that accepts on and off signals.

Input Scaling
The converting of input signals to the engineering units of the process variable.

Input Type
The signal type that is connected to an input, such as thermocouple, RTD or process.

Integral Control (I)
Control action that automatically eliminates offset, or droop, between set point and actual process temperature.

J

Job
A set of operating conditions for a process that can be stored and recalled in a controller's memory. Also called a *recipe*.

Junction
The point where two dissimilar metal conductors join to form a thermocouple.

K

Keypad Lock
A feature that prevents operation of the keypad by unauthorized people.

L

Lag
The delay between the output of a signal and the response of the instrument to which the signal is sent.

Linearity
The deviation in response from an expected or theoretical straight line value for instruments and transducers. Also called *linearity error.*

Load
The electrical demand of a process, expressed in power (Watts), current (Amps) or resistance (Ohms). The item or substance that is to be heated or cooled.

Low Deviation Alarm
Warns that the process has dropped more than a certain amount below set point. It can be used as either an alarm or control function.

Low Alarm
A signal that is associated with a set minimum value that can be used as either an alarm or boost control function.

M

Manual Mode
A selectable mode that has no automatic control aspects. The operator sets output levels.

Manual Reset
A parameter that allows the user to eliminate offset or droop between set point and actual process temperature. See also Integral.

Milliampere (mA)
One thousandth of an ampere.

N

Noise
Unwanted electrical signals that usually produce signal interference in sensors and sensor circuits. See also Electromagnetic Interference.

Noise Suppression
The use of components to reduce electrical interference that is caused by making or breaking electrical contact, or by inductors.

O

Offset
The difference between the set point and the actual value of the process variable. Offset is the error in the process variable that is typical of proportional-only control.

On/Off Control
A method of control that turns the output full on until set point is reached, and then off until the process differs from the set point by more than the hysteresis.

Open Loop
A control system with no sensory feedback.

Optical Isolation
Two electronic networks that are connected through an LED (Light Emitting Diode) and a photoelectric receiver. There is no electrical continuity between the two networks.

Output
Control signal action in response to the difference between set point and process variable.

Output Type
The form of control output, such as time proportioning, distributed zero crossing, Serial DAC or analog. Also the description of the electrical hardware that makes up the output.

Overshoot
The amount by which a process variable exceeds the set point before it stabilizes.

P

PID
Proportional, Integral, Derivative. A control mode with three functions: Proportional action dampens the system response, integral corrects for droops, and derivative prevents overshoot and undershoot.

Polarity
The electrical quality of having two opposite poles, one positive and one negative. Polarity determines the direction in which a current tends to flow.

Process Input
A voltage or current input that represents a straight line function.

Process Variable (PV)
The parameter that is controlled or measured. Typical examples are temperature, relative humidity, pressure, flow, fluid level, events, etc.

Proportional (P)
Output effort proportional to the error from set point. For example, if the proportional band is 20˚ and the process is 10˚ below the set point, the heat proportioned effort is 50 percent. The lower the PB value, the higher the gain.

Proportional Band (PB)
A range in which the proportioning function of the control is active. Expressed in units, degrees or percent of span. See also PID.

Proportional Control
A control using only the P (proportional) value of PID control.

Pulse Input
Digital pulse signals from devices, such as optical encoders.

PV
See Process Variable.

R

Ramp
A programmed increase in the temperature of a set point system.

Range
The area between two limits in which a quantity or value is measured. It is usually described in terms of lower and upper limits.

Recipe
See Job.

Relay
A switching device.

Electromechanical Relay — A power switching device that completes or interrupts a circuit by physically moving electrical contacts into contact with each other. Not recommended for PID control.

Solid State Relay (SSR) — A switching device with no moving parts that completes or interrupts a circuit electrically.

Reset
See Automatic Reset, Manual Reset.

Resistance
Opposition to the flow of electric current, measured in Ohms.

Resistance Temperature Detector (RTD)
A sensor that uses the resistance temperature characteristic to measure temperature. There are two basic types of RTDs: the wire RTD, which is usually made of platinum, and the thermistor, which is made of a semiconductor material. The wire RTD is a positive temperature coefficient sensor only, while the thermistor can have either a negative or positive temperature coefficient.

Reverse Action
An output control action in which an increase in the process variable causes a decrease in the output. Heating applications usually use reverse action.

RTD
See Resistance Temperature Detector.

S

Serial Communications
A method of transmitting information between devices by sending all bits serially over a single communication channel.

Set Point (SP)
The desired value of the process variable. For example, the temperature at which a system is to be maintained.

Shield
A metallic foil or braided wire layer surrounding conductors that is designed to prevent electrostatic or electromagnetic interference from external sources.

Signal
Any electrical transmittance that conveys information.

Solid State Relay (SSR)
See Relay, Solid State.

Span
The difference between the lower and upper limits of a range expressed in the same units as the range.

Stability
The ability of a device to maintain a constant output with the application of a constant input.

T

Thermistor
A temperature-sensing device made of semiconductor material that exhibits a large change in resistance for a small change in temperature. Thermistors usually have negative temperature coefficients, although they are also available with positive temperature coefficients.

Thermocouple (T/C)
A temperature sensing device made by joining two dissimilar metals. This junction produces an electrical voltage in proportion to the difference in temperature between the hot junction (sensing junction) and the lead wire connection to the instrument (cold junction).

Thermocouple Extension Wire
A grade of wire used between the measuring junction and the reference junction of a thermocouple. Extension wire and thermocouple wire have similar properties, but extension wire is less costly.

Transmitter
A device that transmits temperature data from either a thermocouple or RTD by way of a two-wire loop. The loop has an external power supply. The transmitter acts as a variable resistor with respect to its input signal. Transmitters are desirable when long lead or extension wires produce unacceptable signal degradation.

U

Undershoot
The amount by which a process variable falls below the set point before it stabilizes.

V

Volt (V)
The unit of measure for electrical potential, voltage or electromotive force (EMF). See also Voltage.

Voltage (V)
The difference in electrical potential between two points in a circuit. It is the push or pressure behind current flow through a circuit. One volt (V) is the difference in potential required to move one coulomb of charge between two points in a circuit, consuming one joule of energy. In other words, one volt (V) is equal to one ampere of current (I) flowing through one ohm of resistance (R), or V = IR.

Z

Zero Cross
Action that provides output switching only at or near the zero-voltage crossing points of the ac sine wave.

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  thermocouple short alarm 101
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Parameter Address Reference

Use this section to quickly locate addresses for interface software and logic programs.

Parameter	Modbus Address	Parameter Number	LogicPro Driver	Size (bits)	LogicPro Address
Operator Parameters (page 92)					
Set point	40205 to 40213	12	Setpoint	16	1 to 9
Mode	40120 to 40128	7	Database	16	7.1 to 7.9
Heat Output	40273 to 40281	16	Database	16	16.1 to 16.9
Cool Output	40290 to 40298	17	Database	16	17.1 to 17.9
Process Variable	40222 to 40230	13	CPC400_PV	16	1 to 9
Global setup (page 96)					
Load setup from job	44836	111	Database	16	111.1
Save Setup as job	44835	110	Database	16	110.1
BCD Job Load	44837	112	Database	16	112.1
BCD Job Load Logic	44838	113	Database	16	113.1
Mode Override	44839	114	Database	16	114.1
Mode Override Digital Input Active	44840	115	Database	16	115.1
Logic Program	49481	150	Database	16	150.1
Power Up Alarm Delay	40409	24	Database	16	24.1
Power Up Loop Mode	49790, first bit	49	Database	16	49.1, first bit
Power Up With Logic	45308	131	Database	16	131.1
Keypad Lock	40790, second bit	49	Database	16	49.1, second bit
Thermocouple Short Alarm	44842	117	Database	16	117.1
Controller Address	44843	118	Database	16	118.1
Communications Baud Rate	44844	119	Database	16	119.1
Communications Parity	44847	122	Database	16	122.1`
AC Line Frequency	40790, third bit	49	Database	16	49.1, third bit
Digital Output Alarm Polarity	40790, fifth bit	49	Database	16	49.1, fifth bit
Model and Firmware Version	N/A	N/A	N/A	N/A	N/A

Parameter	Modbus Address	Parameter Number	LogicPro Driver	Size (bits)	LogicPro Address
Input (page 104)					
Input Type	40103 to 40111	6	Database	16	6.1 to 6.9
Loop Name	45309 and 45310 for loop 1, 45311 and 45312 for loop 2, and so on	132	Database	16	132.1 and 132.2 for loop1, 132.3 and 132.4 for loop 2, and so on
Input Units	40792, 40793 and 40794 for loop 1; 40795, 40796 and 40797 for loop 2; and so on	51	Database	16	51.1, 51.2 and 51.3 for loop1; 51.4, 51.5 and 51.6 for loop 2; and so on.
Input Pulse Sample	40580	35	Database	16	35.1
Calibration Offset	40649 to 40656	40	Database	16	40.1 to 40.8
Reversed Thermo-couple Detection	44443 to 44450, first bit	86	Database	16	86.1 to 86.8, first bit
Display Format	40666 to 40674	41	Database	16	41.1 to 41.9
Input Range High	40581 to 40589	36	Database	16	36.1 to 36.9
Input High Signal	40615 to 40623	38	Database	16	38.1 to 38.9
Input Range Low	40598 to 40606	37	Database	16	37.1 to 37.9
Input Low Signal	40632 to 40640	39	Database	16	39.1 to 39.9
Input Filter	44409 to 44417	84	Database	16	84.1 to 84.9
Channel (page 109)					
Loop Name	45309 and 45310 for loop 1, 45311 and 45312 for loop 2, and so on	132	Database	16	132.1 and 132.2 for loop1, 132.3 and 132.4 for loop 2, and so on
PV Source	45394 to 45411	136	Database	16	136.1 to136.9
Control (page 111)					
Heat Prop Band	40001 to 40009	0	Database	16	0.1 to 0.9
Cool Prop Band	40018 to 40026	1	Database	16	1.1 to 1.9
Heat Integral	40035 to 40043	2	Database	16	2.1 to 2.9
Cool Integral	40052 to 40060	3	Database	16	3.1 to 3.9
Heat Derivative	40069 to 40077	4	Database	16	4.1 to 4.9
Cool Derivative	40086 to 40094	5	Database	16	5.1 to 5.9
Heat Manual Reset	45274 to 45282	129	Database	16	129.1 to 129.9
Cool Manual Reset	45291 to 45299	130	Database	16	130.1 to 130.9
Heat Filter	40239 to 40247	14	Database	16	14.1 to 14.9

Parameter	Modbus Address	Parameter Number	LogicPro Driver	Size (bits)	LogicPro Address
Cool Filter	40256 to 40264	15	Database	16	15.1 to 15.9
Hysteresis	40856 to 40864	54	Database	16	54.1 to 54.9
Restore Automatic Mode	44460 to 44468	87	Database	16	87.1 to 87.9
Tune Band	46542 to 46550	144	Database	16	144.1 to 144.9
Tune Gain	46559 to 46567	145	Database	16	145.1 to 145.9
Overshoot Reduction	46576 to 46584	146	Database	16	146.1 to 146.9
Control Type	45480 to 45489	139	Database	16	139.1 to 139.9
Output (page 116)					
Heat Output Type	40137 to 40145	8	Database	16	8.1 to 8.9
Cool Output Type	40154 to 40162	9	Database	16	9.1 to 9.9
Heat Cycle Time	40683 to 40691	42	Database	16	42.1 to 42.9
Cool Cycle Time	40700 to 40708	43	Database	16	43.1 to 43.9
Heat SDAC Signal	44307 to 44315	78	Database	16	78.1 to 78.9
Cool SDAC Signal	44324 to 44332	79	Database	16	79.1 to 79.9
Heat SDAC Low Signal	44341 to 44349	80	Database	16	80.1 to 80.9
Cool SDAC Low Signal	44358 to 44366	81	Database	16	81.1 to 81.9
Heat SDAC High Signal	44375 to 44383	82	Database	16	82.1 to 82.9
Cool SDAC High Signal	44392 to 44400	83	Database	16	83. 1 to 83.9
Heat Action	40171 to 40179	10	Database	16	10.1 to 10.9
Cool Action	40188 to 40196	11	Database	16	11.1 to 11.9
Heat Power Limit	44171 to 44179	70	Database	16	70.1 to 70.9
Cool Power Limit	44188 to 44196	71	Database	16	71.1 to 71.9
Heat Power Limit Time	44205 to 44213	72	Database	16	72.1 to 72.9
Cool Power Limit Time	44222 to 44230	73	Database	16	73.1 to 73.9
Sensor Fail Heat Output	44239 to 44247	74	Database	16	74.1 to 74.9
Sensor Fail Cool Output	44256 to 44264	75	Database	16	75.1 to 75.9
Open Thermocouple Heat Output Average	44443 to 44451, second bit	86	Database	16	86.1 to 86.9
Open Thermocouple Cool Output Average	44443 to 44451, third bit	86	Database	16	86.1 to 86.9
Heat Output Curve	44273 to 44281	76	Database	16	76.1 to 76.9
Cool Output Curve	44290 to 44298	77	Database	16	77.1 to 77.9

Parameter	Modbus Address	Parameter Number	LogicPro Driver	Size (bits)	LogicPro Address
Alarms (page 121)					
Alarm High Set Point	40307 to 40315	18	Database	16	18.1 to 18.9
Alarm High Function	See *"Alarm Acknowledge" on page 132* and *"Alarm Function" on page 133*				
Alarm High Output	40426 to 40434	25	Database	16	25.1 to 25.9
High Deviation Value	40341 to 40349	20	Database	16	20.1 to 20.9
High Deviation Function	See *"Alarm Acknowledge" on page 132* and *"Alarm Function" on page 133*				
High Deviation Output	40460 to 40468	27	Database	16	27.1 to 27.9
Low Deviation Value	40358 to 40366	21	Database	16	21.1 to 21.9
Low Deviation Function	See *"Alarm Acknowledge" on page 132* and *"Alarm Function" on page 133*				
Low deviation Output	40477 to 40485	28	Database	16	28.1 to 28.9
Alarm Low Set Point	40324 to 40332	19	Database	16	19.1 to 19.9
Alarm Low Function	See *"Alarm Acknowledge" on page 132* and *"Alarm Function" on page 133*				
Alarm Low Output	40443 to 40451	26	Database	16	26.1 to 26.9
Alarm Hysteresis	40375 to 40383	22	Database	16	22.1 to 22.9
Alarm Delay	40562 to 40570	33	Database	16	33.1 to 33.9
Process Variable Retransmit (page 125)					
Heat Output Retransmit	44478 to 44486	89	Database	16	89.1 to 81.9
Cool Output Retransmit	44495 to 44503	90	Database	16	90.1 to 90.9
Heat Retransmit Low Process Variable	44546 to 44554	93	Database	16	93.1 to 93.9
Cool Retransmit Low Process Variable	44563 to 44571	94	Database	16	94.1 to 94.9
Heat Retransmit High Process Variable	44512 to 44520	91	Data base	16	91.1 to 91.9
Cool Retransmit High Process Variable	44529 to 44537	92	Database	16	92.1 to 92.9

Parameter	Modbus Address	Parameter Number	LogicPro Driver	Size (bits)	LogicPro Address
Cascade (page 127)					
Cascade Primary Loop	44648 to 44654	99	Database	16	99.1 to 99.9
Cascade Low Set Point	44682 to 44690	101	Database	16	101.1 to 101.9
Cascade High Set Point	44699 to 44707	102	Database	16	102.1 to 102.9
Ratio (page 128)					
Ratio Master Loop	44750 to 44758	105	Database	16	105.1 to 105.9
Ratio Low Set Point	44767 to 44775	106	Database	16	106.1 to 106.9
Ratio High Set Point	44784 to 44792	107	Database	16	107.1 to 107.9
Control Ratio	44801 to 44809	108	Database	16	108.1 to 108.9
Ratio Set Point Differential	44818 to 44826	109	Database	16	109.1 to 109.9
Soft Integers (page 130)					
Soft Integer Value	44883 to 44982 (Soft integers 1 to 100) 45496 to 46495 (Soft integers 101 to 1100)	126 (Soft integers 1 to 100) 140 (Soft integers 101 to 1100)	Soft_Int	16	1 to 1100
Soft Booleans (page 131)					
Soft Boolean Value	44983 to 45238	127	Soft_Bool	1	1 to 256
I/O Tests (page 131)					
Digital Inputs	40719 to 40726	46	CPC400_Digital_In	1	1 to 8
Keypad Test	N/A	N/A	N/A	N/A	N/A
Test Digital Output 1 to 35	40751 to 40785	47	CPC400_Digital_Out	1	1 to 35
Additional Parameters for Serial Communications and LogicPro Programs (page 132)					
Alarm Acknowledge	40511 to 40519	30	Database	16	30.1 to 30.9
Alarm Enable	40528 to 40536	31	Database	16	31.1 to 31.9
Alarm Function	40494 to 40502	29	Database	16	29.1 to 29.9
Alarm Status	40392 to 40400	23	Database	16	23.1 to 23.9
Ambient Sensor Reading	40579	34	Database	16	34.1
Analog Input	45375 to 45383	135	Database	16	135.1 to 135.9

Parameter	Modbus Address	Parameter Number	LogicPro Driver	Size (bits)	LogicPro Address
Data Changed Register	40791	50	Database	16	50.1
Firmware Identification	40847	52	Database	16	52.1
Firmware Version (page 135)					
Major Part	40844	52	Database	16	52.2
Minor Part	40845	52	Database	16	52.3
Revision Letter	40846	52	Database	16	52.4
Full Scale Calibration	40718	45	Database	16	45.1
System Status	40786 (first to eighth bit), 40787 (ninth to sixteenth bit)	48	Database	16	48.1 (first to eighth bit), 48.2 (ninth to sixteenth bit)
Zero Calibration	40717	44	Database	16	44.1

Declaration of Conformity

CPC400 Series

CE

WATLOW ANAFAZE
314 Westridge Drive
Watsonville, California 95076 USA

Declares that the following product: ***English***

Designation:	CPC400 Series
Model Number(s):	40 (4, or 8) - (1) (0,1 or 2) (0 or 2) (0,1,2 or 3) (0,1,2 or 3) (0,1, or 2) (any letter or number)
Classification:	Installation Category II, Pollution Degree II
Rated Voltage:	12 to 24V⎓ (dc)
Rated Current:	610mA maximum

Meets the essential requirements of the following European Union Directive(s) using the relevant section(s) of the normalized standards and related documents shown:

89/336/EEC Electromagnetic Compatibility Directive

EN 61326:	**1997**	**Electrical equipment for measurement, control and laboratory use - EMC requirements (Class A)**
EN 61000-3-2:	1995	Limits for harmonic current
EN 61000-3-3:	1995	Limitations of voltage fluctuations and flicker
EN 61000-4-2:	1995	Electrostatic discharge
EN 61000-4-3:	1997	Radiated immunity
EN 61000-4-4:	1995	Electrical fast transients
EN 61000-4-5:	1995	Surge immunity
EN 61000-4-6:	1994	Conducted immunity
EN 61000-4-11:	1994	Voltage dips, short interruptions and voltage variations immunity
ENV 50204:	1995	Cellular phone

Déclare que le produit suivant : ***Français***

Désignation :	Série CPC400
Numéro(s) de modèle(s):	40 (4 ou 8) - (1) (0,1 ou 2) (0 ou 2) (0, 1, 2 ou 3) (0, 1, 2 ou 3) (0, 1, ou 2) (lettre ou chiffre quelconque)
Classification :	Installation catégorie II, degré de pollution II
Tension nominale :	12 à 24V c.c.
Courant nominal :	610 mA maximum

Conforme aux exigences de la (ou des) directive(s) suivante(s) de l'Union Européenne figurant aux sections correspondantes des normes et documents associés ci-dessous :

89/336/EEC Directive de compatibilité électromagnétique

EN 61326:	**1995**	**Appareillage électrique pour la mesure, la commande et l'usage de laboratoire —— Prescriptions relatives à la Compatilité Electro Magnétique (Classe A)**
EN 61000-3-2 :	1995	Limites d'émission de courant harmonique
EN 61000-3-3 :	1995	Limites de fluctuation de tension
EN 61000-4-2 :	1995	Décharge électrostatique
EN 61000-4-3:	1997	Insensibilité à l'énergie rayonnée
EN 61000-4-4 :	1995	Courants électriques transitoires rapides
EN 61000-4-5 :	1995	Insensibilité aux surtensions
EN 61000-4-6:	1996	Insensibilité à l'énergie par conduction
EN 61000-4-11 :	1994	Insensibilité aux chutes subites, aux courtes interruptions et aux variations de tension
ENV 50204 :	1995	Téléphone cellulaire

Erklärt, daß das folgende Produkt: ***Deutsch***

Beschreibung:	Serie CPC400
Modellnummer(n):	40 (4 oder 8) - (1) (0,1 oder 2) (0 oder 2) (0,1,2 oder 3) (0,1,2 oder 3) (0,1, oder 2) (beliebige Buchstaben oder Ziffern)
Klassifikation:	Installationskategorie II, Emissionsgrad II
Nennspannung:	12 bis 24 Vdc
Nominaler Stromverbrauch:	max. 610 mA

Erfüllt die wichtigsten Normen der folgenden Anweisung(en) der Europäischen Union unter Verwendung des wichtigsten Abschnitts bzw. der wichtigsten Abschnitte der normalisierten Spezifikationen und der untenstehenden einschlägigen Dokumente:

89/336/EEC Elektromagnetische Übereinstimmungsanweisung

EN 61326:	**1997**	**Elektrogeräte zur Messung, Regelung und zum Laboreinsatz EMC - Richtlinien (Klasse A)**
EN 61000-3-2:	1995	Grenzen der Oberwellenstromemissionen
EN 61000-3-3:	1995	Grenzen der Spannungsschwankungen
EN 61000-4-2:	1995	Elektrostatische Entladung
EN 61000-4-3:	1997	Strahlungsimmunität
EN 61000-4-4:	1995	Elektrische schnelle Stöße
EN 61000-4-5:	1995	Spannungsstoßimmunität
EN 61000-4-6:	1994	Störimmunität
EN 61000-4-11:	1994	Immunität gegen Spannungsgefälle, kurze Unterbrechungen und Spannungsabweichungen
ENV 50204:	1995	Mobiltelefon

Declara que el producto siguiente: ***Español***

Designación:	Serie CPC400
Números de modelo:	40 - (4 ó 8) - (1) (0,1 ó 2) (0 ó 2) (0,1,2 ó 3) (0,1,2 ó 3) (0,1, ó 2) (Cualquier letra ó numero)
Clasificación:	Categoría de instalación II, grado de contaminación ambiental II
Tensión nominal:	12 a 24Vcc
Consumo nominal de energía:	610 mA máximo

Cumple con los requisitos esenciales de las siguientes Directivas de la Unión Europea, usando las secciones pertinentes de las reglas normalizadas y los documentos relacionados que se muestran:

89/336/EEC - Directiva de Compatibilidad Electromagnética

EN 61326:	**1997**	**Equipo elétrico para medición control y uso en laboratorios - Requisitos de compatibilidad electromagnética (Clase A)**
EN 61000-3-2	1995	Límites para emisiones de corriente armónica
EN 61000-3-3	1995	Limitaciones de fluctuaciones del voltaje
EN 61000-4-2:	1995	Descarga electrostática
EN 61000-4-3:	1997	Inmunidad radiada
EN 61000-4-4:	1995	Perturbaciones transitorias eléctricas rápidas
EN 61000-4-5:	1995	Sobretensión
EN 61000-4-6:	1994	Inmunidad conducida
EN 61000-4-11:	1994	Caídas de tensión, interrupciones breves y variaciones de tensión
ENV 50204:	1995	Teléfono portátil

Sean Wilkinson
Name of Authorized Representative

Watsonville, California. USA
Place of Issue

Manager
Title of Authorized Representative

Feb 28, 2003
Date of Issue

Signature of Authorized Representative

Menu Structure

Global setup (page 96)
Load setup from job
Save setup as job
BCD job load
BCD job load logic
Mode override
Mode override D/I active
Logic program
Power up alarm delay
Power up loop mode
Power up with logic
Keypad lock
TC short alarm
Controller address
Comm baud rate
Comm parity
AC line freq
D/O alarm polarity
CPC4xx Vx.xxX cs=xxxx

Input (page 104)
Input type
Input units
Input pulse sample
Calibration offset
Reversed T/C detect
Disp format
Input range high
Input high signal
Input range low
Input low signal
Input filter

Channel (page 111)
Loop name
PV source

Control (page 111)
Heat prop band
Heat integral
Heat derivative
Heat manual reset
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Cool prop band
Cool integral
Cool derivative
Cool manual reset
Cool filter
Hysteresis
RestoreAuto
Tune band
Tune gain
Overshoot reduction
Control type

Output (page 116)
Heat output type
Heat cycle time
Heat SDAC signal
Ht SDAC low signal
Ht SDAC hi signal
Heat action
Heat power limit
HtPwr limit time
Sensor fail heat output
Open T/C ht out average
Heat output curve
Cool output type
Cool cycle time
Cool SDAC signal
Cl SDAC low signal
Cl SDAC hi signal
Cool action
Cool power limit
ClPwr limit time
Sensor fail cool output
Open T/C cl out average
Cool output curve

Alarms (page 121)
Alarm high SP
Alarm high func
Alarm high output
HiDeviation value
HiDeviation func
HiDeviation output
LoDeviation value
LoDeviation func
LoDeviation output
Alarm low SP
Alarm low func
Alarm low output
Alarm hysteresis
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PV retrans (page 125)
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Ht retrans LowPV
Ht retrans HighPV
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Cl retrans HighPV

Cascade (page 127)
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Cascade low SP
Cascade hi SP

Ratio (page 128)
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Ratio high SP
Control ratio
Ratio SP diff

Soft integers (page 130)
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...
Soft int 100 value

Soft Booleans (page 131)
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...
Soft Bool 256 value

I/O tests (page 131)
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...
Test D/O 35